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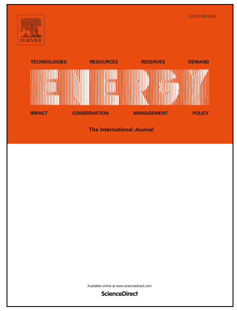

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Abstract

In this paper, we investigate the nature of asymmetry in the influence of oil price changes on output in six MENA countries. To get more observations for our analysis, we proxy GDP with industrial output and hence our inference is based on a relatively larger sample compared to previous studies. The results that we obtain are interesting and intuitive. First, we find that growth in MENA countries is linked to oil in the sense that it benefits from higher oil prices and it gets hurt by a fall in the oil market. Moreover, there are pronounced short- and long-term asymmetries in the influence of oil on output. In particular, the output is faster to respond to increases in the oil price than it responds to decreases. The long-term influence to a rise in oil is also higher, though it is realized over a longer period. These results are important and can be used to guide policies that are concerned with stabilizing the economies of the MENA region against oil price fluctuations.[1]

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1. Introduction

In the literature, there is extensive evidence that in oil importer countries, rises in the price of oil trigger economic recessions, while its fall is unlikely to start a comparable economic expansions.[2] These asymmetries in the response of output to the change in the price of oil are surprising as the purchasing power of oil importers rises and falls by the same amount after similar positive and negative changes in the price of oil.[3] Therefore, one would expect the response of output to the same exogenous negative and positive oil shocks to be asymmetric in the oil importing as well as the oil exporting countries.

Many explanations have been provided in the literature.[4] For instance, Hamilton (1988) attributed asymmetry to the reallocation effects that accompany the changes in the relative prices with respect to oil. A shock to oil disturbs the relative values and it leads to reallocation of resources which is costly for the economy. In an oil importer economy, this exacerbates the bad influence of an increase in the oil price and it reduces the positive impact following its decline. Another explanation of asymmetry is provided by Bernanke (1983) who has explained it by the increase in uncertainty following oil price changes.[5] Edelstein and Kilian (2009) explained the asymmetry in the context of the employment uncertainty and the increases in the precautionary savings after an unexpected change in the price of oil. In both Bernanke (1983) and Edelstein and Kilian (2009) uncertainty tends to lessen expansions after oil declines and to worsen recessions after oil market rallies.

[2] See for instance, Bernanke et al. (1997); Hamilton (1988), Balke, Brown and Yücel (2002), Edlestein and Kilian (2009), Kilian and Vigfusson (2009), Elder and Serletis (2010), Kilian & Vigfusson (2011a,b, 2013), Herrera, et al. (2011, 2015), Baumeister and Kilian (2016), Baumeister et al. (2018), and Baumeister and Hamilton (2019) among many others.

[3] Note that with the increase in the oil price, resources are transferred from oil importing countries to oil exporting countries. Hence, the purchasing power decreases and increases for oil importers and exporters respectively.

[4] Herrera et al. (2019) provide a comprehensive survey of the literature.

[5] In a recent study, Maghyereh and Abdoh (2020) find that uncertainty reduces investment spending in energy sectors.

In the literature, the analysis of asymmetry focuses on net oil importing countries and there is little evidence on whether the response of output to oil shocks is asymmetric in oil exporting regions. Hence, it is interesting to investigate asymmetries in oil exporters and whether it can be explained by reallocation effects, uncertainty effects and monetary policy effects. The only difference is that in oil abundant regions, oil is expected to be positively related to output and hence, oil price declines are likely to trigger recessions whereas its increases are expected to be expansionary.

The literature on how oil price changes influence GDP in the context of MENA countries is still underdeveloped.[6] However, there is a group of studies which found that the negative influence of oil price falls is more pronounced than the positive influence of its rises. This surprising result is explained by the increase in the rent-seeking behavior, poor policies and reallocation effects that accompany the rise in oil. Moreover, the rise in the oil price increases government investment spending and this crowd out private capital and investments with negative repercussions on economic growth.

Therefore, in this paper, we contribute to the current literature by focusing on asymmetry in oil exporting rather than in oil importing countries as it is customary in the literature.[7] The aim is to give a new evidence and to provide some theoretical discussion as to why asymmetric responses of output may also occur in oil exporters. For that purpose, we look into a sample of six countries in the MENA region. These countries are: Saudi Arabia, UAE, Kuwait, Qatar, Egypt and Tunis. The first four of these countries are net oil exporters and hence our sample fits for our purpose. It is widely believed that the MENA region is an oil region and that higher oil prices are good for its trade, investment, and economic growth.

[6] Most studies on oil in the MENA region focus on the relationship between oil and equities. See for instance, Maghyereh, and Al□Kandari (2007); Arouri and Rault (2010); Akoum et al. (2012); Awartani and Maghyereh (2013); Jouini and Harrathi (2014); Maghyereh and Awartani (2016); Awartani et al. (2018); Maghyereh et al. (2018, 2019).

[7] Only Nusair (2016) focuses on asymmetry in the MENA region. The rest of the literature is only concerned with the relationship between oil and output. The literature review section that is following contains more details.

Hence, studying asymmetry to oil price changes in this region is indicative of the extent of the reallocation, the uncertainty and the monetary policy effects that accompany the changes in the oil price.

The rest of the paper is organized as follows: In Section 2 a synopsis of the literature on the oil-output nexus is provided. Section 3 discusses the methodology we employed. The data set and its characteristics will be provided in section 4. In Section 5, we present the empirical findings. Section 6 checks the robustness of results under a different data generating process. Finally, we provide our conclusion in Section 7.

2. Literature Review

A particular feature that is substantiated in the academic literature of oil importers is the distinctive reaction of economic growth to negative and positive oil price shocks. A phenomenon that is termed in the literature as asymmetry (See, Hamilton, 1988; Bernanke, 1983; Lardic and Mignon, 2008). Specifically, it is found that while oil price increases may cause the economy to slow down, similar decreases in the oil price do not trigger economic acceleration.

In oil exporter countries, there are many studies that focus on the relationship between oil and output. However, few of these has been concerned with investigating and explaining asymmetry in the response of output to oil price shocks.[8] The same applies to the oil—output studies in the MENA region.

For instance, the studies by Mehrara (2008) and Moshiri and Banijashem (2012) find that while output growth is negatively affected by a fall in the oil market, its response to rise is weak and negligible. Cologni and Manera (2013) used error correction model analysis to show that oil and output are cointegrated in oil abundant countries. The study by Esfahani et al. (2014) find a long-term relationship between the real oil price and the real output in eight

[8] Allegret et al. (2014), Korhonen and Juurikkala (2009), Farzanegan and Markwardt (2009), El Anshasy and Bradley (2012), Mohaddes and Pesaran (2016, 2017), and Maghyereh et al. (2020).

major oil exporter countries around the globe. Nusair (2016) has also found strong interlinkages between oil and output in the GCC countries.[9] Recently, Mohaddes and Raissi (2016) have studied the impact of low oil prices on country economic growth globally by using the GVAR model. Their results indicate that the economies of MENA oil exporters have slowed by approximately 1.32% following the drop in the oil price that resulted from the start of shale oil production in the US.[10]

The results of the studies on the oil-output nexus in the MENA countries suffer from the small sample size bias. The parameter estimates of the impact and their standard errors may be inaccurate and it suffers from parameter estimation errors despite their consistency. For instance, Mehrara's (2008) sample is 40 observations, Moshiri and Banijashem's (2012) sample is 31 observations, Cologni and Manera's (2013) sample is 51 observations and Nusair's (2016) sample is 30 observations.

In this paper, we overcome these problems of data limitations by using the industrial output to proxy real GDP. The industrial output is available at the monthly frequency and it may not deviate from the state of the economy for a long period of time and hence, it is closely related to real output particularly in the longer term. Thus, our sample does not suffer from the small sample bias as it contains more observations. In addition, for the purpose of comparison, we include Egypt and Tunis and we have provided a full account and explanation of our findings. In our analysis, we also focus on the period that followed the global financial crisis and our samples extend from 2006 to 2018 depending on the country. Finally, our focus is on asymmetry and we provide a complete account for this issue.

3. Methodology

[9] The GCC is an economic block of oil producing countries that include Saudi Arabia, Kuwait, United Arab Emirates, Oman, Bahrain and Qatar.

[10] Many cross-countries studies investigate the relationship between oil prices and economic growth. For instance, Mohaddes and Pesaran (2016, 2017); Berument et al. (2010); Baumeister et al. (2010); Peersman and Van Robays (2012); Vespignani (2015); Verspignani and Ratti (2016); and Maghyereh et al. (2019).

The asymmetric bound-testing approach in the context of NARDL which is developed by Shin et al. (2014) is used in the current study to test for asymmetry. The NARDL framework utilizes negative and positive partial sum decompositions of the independent variables and this enables us to easily detect asymmetric interactions between the variables in the short- and the long-run. The bounds testing in the NARDL requires the variables to be integrated of order 0 or 1. The integration order of variables and its stationarity are checked by the Lagrange Multiplier unit root test of Lee and Strazicich (2003). The test allows for structural break and non-linearity in the data. In this section, we briefly describe NARDL model and the LM unit root test.

3.1 NARDL framework

Suppose that IP_t , OP_t , INF_t and R_t are the real industrial production, the real oil prices, the inflation rate and real lending rate in a particular MENA country.[11] Following Shin et al. (2014), a simple asymmetric long run relationship between oil and output can be written as

$$IP_t = \beta^+ OP_t^+ + \beta^- OP_t^- + \gamma_1 INF_t + \gamma_2 R_t + u_t \tag{1}$$

$$\Delta OP_t = \vartheta_t \tag{2}$$

In this specification, the variable are assumed to have one cointegrating relationship. Instead of having the long run relationship with the level of the oil price OP_t, it is modelled with the partial sums of the negative OP_t^- and the positive OP_t^+ oil price processes, $OP_t = OP_0 + OP_t^- + OP_t^+$. These partial sums are computed as

$$OP_t^+ = \sum_{j=1}^{t} \Delta OP_j^+ = \sum_{j=1}^{t} \max\left(\Delta OP_j, 0\right); OP_t^- = \sum_{j=1}^{t} \Delta OP_j^- = \sum_{j=1}^{t} \min\left(\Delta OP_j, 0\right)$$

If the $|\beta^+| \neq |\beta^-|$ in equation 1, then similar increases and decreases in the oil price will not have the same impact on output. The MENA output is not expected to drive the oil price and hence, we do not expect an endogeneity problem, but the model in 1 lacks the short term

[11] All quantities are denominated in the domestic currency of the relevant country.

dynamics. Hence, the nonlinear dynamic autoregressive distributed lag model (NARDL) of Shin et al. (2014) is more suitable as it accounts for asymmetry, the long and the short-term dynamics.

The non-linear $ARDL(p,q,r,s)$ can be written as

$$IP_t = \sum_{j=1}^{p} \emptyset_j IP_{t-j} + \sum_{j=0}^{q} \left(\theta_j^{+\prime} OP_{t-j}^{+} + \theta_j^{-\prime} OP_{t-j}^{-}\right) + \sum_{i=0}^{r} \delta_i INF_{t-i} + \sum_{i=0}^{s} \omega_i R_{t-i} + \varepsilon_t \quad (3)$$

where OP_t is defined as $OP_0 + OP_t^- + OP_t^+$, and $\emptyset_j$'s are the autoregressive parameters that capture the own dynamics of the growth process. The θ_j^+ and θ_j^- are the asymmetric distributed lag parameters that measure the influence of positive and negative partial sums of the oil prices OP_t^+ and OP_t^- on the industrial output. In Eq. 3, ε_t is assumed to follow an iid process with zero mean and constant variance, σ_ε^2.

The relationship in 3 can be re-written as:[12]

$$\Delta IP_t = \rho IP_{t-1} + \gamma_1 INF_{t-1} + \gamma_2 R_{t-1} + \theta^{+\prime} OP_{t-1}^{+} + \theta^{-\prime} OP_{t-1}^{-} + \sum_{j=1}^{p-1} \gamma_j \Delta IP_{t-1} + \sum_{j=0}^{q-1} \left(\varphi_j^{+\prime} \Delta OP_{t-j}^{+} + \varphi_j^{-\prime} \Delta OP_{t-j}^{-}\right) + \sum_{i=0}^{r} \delta_i \Delta INF_{t-i} + \sum_{i=0}^{s} \omega_i \Delta R_{t-i} + \epsilon_t \quad (4)$$

where $\rho = \sum_{j=1}^{p} \emptyset_j - 1, \gamma_j = -\sum_{i=j+1}^{p} \emptyset_i$ for $j = 1, \dots, p-1, \theta^+ = \sum_{j=0}^{q} \theta_j^+, \theta^- = \sum_{j=0}^{q} \theta_j^-, \varphi_0^+ = \theta_0^+, \varphi_j^- = -\sum_{i=j+1}^{q} \theta_j^-$ for $j = 1, \dots, q-1$.

Note that Eq. 4 is actually an error correction formulation of the relationship between oil and industrial production which may be written as

$$\Delta IP_t = \rho ECT_{t-1} + \sum_{j=1}^{p-1} \gamma_j \Delta IP_{t-1} + \sum_{j=0}^{q-1} \left(\varphi_j^{+\prime} \Delta OP_{t-j}^{+} + \varphi_j^{-\prime} \Delta OP_{t-j}^{-}\right) + \sum_{i=0}^{r} \delta_i' \Delta INF_{t-i} + \sum_{i=0}^{s} \omega_i' \Delta R_{t-i} + \epsilon_t \quad (5)$$

[12] It is straightforward to get Eq. 4 from Eq. 3 following Pesaran et al. (2001).

where the cointegrating vector is written as $ECT_t = IP_t - \beta^{+'} OP_t^{+} - \beta^{-'} OP_t^{-} - \gamma_1' INF_t - \gamma_2' R_t$. The parameters $\beta^{+} = \frac{-\theta^{+}}{\rho}$ and $\beta^{-} = \frac{-\theta^{-}}{\rho}$ are the corresponding long-term parameters.[13] By including an appropriate lag structure in 8, we may free the model from potential serial correlations in the residuals.

Note that when ρ in 5 is zero, there is no cointegration between oil and output. This implies that the oil price changes have no influence on output in the long term. An F test for the null of $\rho = \theta^{+\prime} = \theta^{-\prime} = 0$ has been proposed by Pesaran et al. (2001) and we will refer to this test as F_{PSS} test. A value of the computed test statistics that lies beyond these bounds implies that oil and output are not cointegrated and a value between these bounds implies inconclusiveness.

Another nonstandard test for the long term cointegration has been also proposed by Banerjee et al. (1998) who suggest testing the null of $\rho = 0$ against $\rho < 0$ in 5, we denote this test as the t_{BDM} test. Both of these tests will be used to infer cointegration between oil price changes and output. Finally, we test for long- and short-term asymmetry using a standard Wald test of the relevant parameters.[14]

The specification in Eq. 5 is appropriate for our purpose as it is able to capture, the short-term and the long-term dynamics and asymmetry in the relationship between the oil price and industrial output. As the model is linear in terms of all of its parameters, it can be estimated by a standard OLS estimator.

3.2 LM unit root test

The ADF unit root test has low power if there are nonlinearities or structural breaks (See, Perron, 1989; Nazlioglu, 2011). To improve the power of the unit root test, we further depend

[13] The bias in case of endogeneity can be easily corrected by using instrumental variables.

[14] The null for the long-term asymmetry test is $\beta^{+} = \beta^{-}$ and for the short-term asymmetry is $\sum_{j=0}^{q_1} \varphi_j^{+\prime} = \sum_{j=0}^{q_2} \varphi_j^{-\prime}$.

on the Lee and Strazicich (2003) LM unit root test. This test allows for the endogenous determination of the size and the time of structural breaks both in the level and in the trend of the data generating process.

Consider the following data generating process:

$$y_t = \delta' Z_t + \varepsilon_t, \quad \varepsilon_t = \beta \varepsilon_{t-1} + u_t, \qquad u_t \sim iidN(0, \sigma^2) \tag{6}$$

where Z_t, is a vector of exogenous variables that define the data generating process. The test for unit roots is based on the parameter β and the null hypothesis is $\beta = 1$. To accommodate a structural break in the intercept and a change in the slope of the trend, the vector of exogenous variables Z_t is specified as $Z_t = [1, t, D_t, DT_t]'$, where $DT_t = t - T_B$ for $t > T_B + 1$, and zero otherwise. The T_B here denotes the time period when the break occurs. To endogenously determine the location of the break, the LM unit-root procedure searches all possible break points with minimum unit-root *t*-test statistic in order to find the greatest lower bound such that:[15]

$$LM_\tau = Inf\ \tilde{\tau}(\tilde{\lambda}) = Inf_\lambda \tau\lambda, \qquad \text{where } \lambda = T_B/T \tag{7}$$

4. Data Set

We obtain monthly data on the WTI crude oil prices, the industrial production, the lending rate and the inflation rate from Thomson Reuters Datastream. A complete data set is found for six MENA countries. These countries are Egypt, Tunis, the United Arab Emirates, Saudi Arabia, Kuwait, and Qatar.[16]

We find data for Egypt from November 2010 to June 2018 for a total of 89 monthly observations. The data for Saudi Arabia starts in December 2006, but it ends in October 2018 and hence, we have found 119 monthly observations. The rest of the samples are as follows: the UAE data is available from January 2008 to October 2016, for a total of 105 observations;

[15] The critical values of the LM unit root test statistics are tabulated in Lee and Strazicich (2003).

[16] A full data set for the rest of other MENA countries are not available on a monthly basis.

The Kuwaiti data from July 2009 to October 2016 for a total of 88 observations; The Tunisian data from October 2007 to March 2018 for a total of 125 observations; and finally, the Qatari data from January 2009 to October 2016 for a total of 96 observations.

The monthly consumer price index and the monthly foreign exchange rate against the dollar are used in order to get real output and real oil prices denominated in the domestic currency of the relevant country. The lending rate above the inflation is used in order to get the real rate.

Figure 1 displays how the real industrial output changes with real oil prices. The stacked diagrams show that the industrial output of the MENA economies expands with the increase in the price of oil and shrinks with its decrease. This pattern of the relationship is uniform across countries and it is more pronounced during large draw ups and large drawdowns in the real price of oil.[17]

[INSERT FIGURE 1 HERE]

Table 1 presents summary statistics of the log real oil price, industrial production, inflation and the real lending rate of the countries in the sample. The table shows that the real oil price is negatively skewed and its kurtosis is slightly above the kurtosis of a normal. The Jarque-Bera statistics reject the normality of the oil price at conventional levels. Industrial production does not have a consistent pattern across countries. It is positively skewed in Egypt, Tunisia, and Saudi Arabia, but it is negatively skewed in the UAE, Qatar and Kuwait.

[INSERT TABLE 1 HERE]

Table 2 displays the Augmented Dicky Fuller Test of unit roots in the levels, the first differences and the second differences of the variables. The null hypothesis is not rejected for the level of output and oil but it is strongly rejected at the 1% level for the first differences. The real lending rates and the inflation rates are stationary. Surprisingly, the first difference

[17] It is well known that the MENA region depends on oil. The rise in oil benefits economic growth in the region through cross country foreign direct investment, trade and employment.

of the Kuwaiti and Saudi industrial output are covariance non-stationary, but the second differences are found to be stationary.

[INSERT TABLE 2 HERE]

The results Lee and Strazicich unit root test with one endogenous structural break are presented are all reported in Table 3. The t-statistics associated with the LM test presented in Column 2 shows that all variables are non-stationary, but their first difference is stationary at the 1% significance level.[18]

Columns 4 and 5 of Table 3 report the dates of structural breaks as determined econometrically by the procedure. As can be seen in the table, the breaking dates of the levels and the differences of the variables are different across countries. Columns 6 and 7 display the test results when breaks exists in the level of the data generating process. Similarly, the test results for breaks in the trend of the data are presented in Columns 8 and 9. As can be seen in all columns the null of unit root is uniformly rejected across countries at the 5% significance level.

[INSERT TABLE 3 HERE]

In the NARDL model in 5, we regress output on the cumulative negative and positive changes of the oil price. Hence, for a valid inference, it would be necessary to test for unit roots in the negative and positive partial sum processes of the oil price.[19] These tests are presented in Table 1A in Appendix A, and it shows stationary positive and negative partial sums in oil price changes which implies non stationarity at the level of these variables as assumed by the NARDL model.

The BDS test of Brock et al. (1996) shows pronounced nonlinearity in all series, thus providing further justification for the NARDL non-linear functional form.[20]

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[18] In the NARDL model variables are assumed to be integrated of order 1. As our variables are I(1), we may safely proceed to estimate and infer the oil-output relationship from the model.
[19] This point has been brought to our attention thankfully by one of the referees.
[20] To save on space, these results are not reported but available from the authors upon request.

5. Empirical Findings

5.1 Preliminary analysis

Table 4 presents the non-parametric Granger causality test of Bekiros and Diks (2008). The table shows that the influence of the changes in the price of oil is significant at the 5% level in all sample countries.

[INSERT TABLE 4 HERE]

The only information you get from this classical Granger causality test is whether the oil price changes impact the future economic growth or not, but it does not reveal any potential asymmetries in the causal relationship between the variables.[21] A particular test that is different and revealing is the Hatemi-J (2012) test which is based on the cumulative negative and positive sums of the changes in the oil price and the industrial output processes. Figure 2 displays the cumulative negative and positive sums of oil and output.

[INSERT FIGURE 2 HERE]

In the Hatemi-J (2012) test, the positive and the negative processes of the real output and the oil price are modelled as VAR-SUR processes in which the previous positive and negative output and oil influence the future positive and negative changes in output and oil. Thus, the model allows for a Wald test of asymmetric causality in the usual form. The test may run over from OP^{+} to IP^{+} or over any other combination. However, as the output and the oil price are not normal, the Chi-squared critical values of the Wald test statistics may be biased. Therefore, we follow Hatemi-J (2012) and employ a bootstrap algorithm with leverage corrections in order to get accurate critical values.[22]

[21] The unsuitability of standard causality tests for checking causal asymmetric relationships has been thankfully pointed to us by one of the referees.
[22] The technical details of this test can be found in Hatemi-J (2012), Hatemi-J, A. (2014) and Hatemi-J, A. and El-Khatib Y. (2016).

Table 5 presents the test results.[23] As expected an increase in the oil price leads to more growth in all sample countries except Tunis where growth slows down. Tunis is a net importer of oil and this explains the negative effect of a hike in the prices of energy on its small economy.[24] The economies of oil exporters expand and contract after increases and decreases in the price of oil. However, increases in oil hurt the output and the production of net oil importer economies by more than these economies are benefiting from energy price decreases.[25] The test also shows that the influence of a decrease in the oil price is more significant than the impact of an increase except for Kuwait. This indicates that oil price increases are less likely to benefit growth but oil price decreases are highly likely to slow the economy in the sample countries.

[INSERT TABLE 5 HERE]

5.2 Main results

Now, we proceed to estimate the NARDL as in Eq. 5. Table 6 presents the estimation results. The table shows that the model fits the data well. The diagnostics of the errors indicate no serial correlation, no heteroskedasticity and suitable functional form.[26] Table 6 shows that the real industrial output and the real oil price are cointegrated in Saudi Arabia, the UAE, and Tunisia. The t_{BDM} test statistics rejects the null of no cointegration at the 5% significance level.[27] The same result is inferred from the F_{PSS} bounds test. The two countries that are found with weak cointegration evidence are Egypt and Kuwait.

[23] We use GAUSS codes to run the test. The authors are grateful to A. Hatemi-J for providing the codes necessary to conduct this analysis.
[24] Tunis produces some oil from El Borma and Ashtart fields, but it imports large proportions of its oil needs from Libya.
[25] Similar results from the recent literature on the positive impact of oil increases on oil exporter countries can be found in Farzanegan and Markwardt (2009), Korhonen and Juurikkala (2009), El Anshasy and Bradely (2012), Allegret et al. (2014), and Nusair (2016).
[26] The lags of the partial sums of oil and output are chosen using the AIC information criteria which is checked up to a max p = max q = 12. Then all insignificant stationary regressors are dropped from the model.
[27] As mentioned previously here we test the null of $\rho = 0$ against the alternative of < 0 . The parameter ρ is the adjustment speed parameter that is associated with the error correction term in the non-linear ARDL model.

The estimated long-term non-linear relationship has similar characteristics across countries. Output increases and decreases with the increases and the decreases in the oil price. However, the output is more sensitive to oil price rallies than to oil price falls. The Table 6 shows that the estimated long -term response of industrial production to a 1% increase in the partial sum of positive changes in the real oil price is 0.40%, -0.38%, 0.42%, 0.40%, 0.32%, 0.17% for Egypt, Tunisia, UAE, Saudi Arabia, Kuwait, and Qatar respectively. This can be compared with an output response of -0.15%, 0.09%, -0.07%, -0.24%, -0.21%, -0.14% and -0.10% that result from a decrease in the oil price of the same countries respectively.

There is a contemporaneous influence of oil on the real output of net exporters of the MENA region. The influence is significant during increases as well as decreases in the real price of oil. Occasionally, the partial sums of the previous changes in the oil price do influence current real industrial production. For instance, oil price positive and negative changes at two lags seem to be significant in Saudi Arabia. Similarly, negative changes in partial sums of the real oil price at four lags negatively influence the industrial production of Kuwait and positively influence the industrial production of Tunisia.

[INSERT TABLE 6 HERE]

The influence of control variables is found to be in line with the related literature. The changes in the inflation rate influence positively the industrial production of all MENA countries. For instance, long -term response of industrial production to a 1% change in the inflation rate is 2.63%, 1.13%, 1.37%, 2.63% and 4.26% in Saudi Arabia, Kuwait, UAE, Egypt, and Tunisia respectively. Among the sample countries, Tunisia's industrial production is the most sensitive to inflation rate fluctuations. The lending interest rate is found to be significantly negatively associated with output of Saudi Arabia, Kuwait, UAE and Egypt. A 1% increase in rates depresses the long-run industrial production of UAE, Saudi Arabia, Egypt and Kuwait by -3.19%, -2.53%, -1.53% and -1.50% respectively.

The long- and short-term asymmetry tests are included in Table 7. The table shows that there is substantial asymmetry in the response of MENA output to the oil prices in the short and long term. This result is significant and uniform across all countries. The only exception is the response of Tunisian industrial output which seems to be symmetric, but only in the short run.

The adjustment and uncertainty effects are expected to detract income growth following an oil price increase and to exacerbate the negative impact after oil price decreases. However, these theoretical guesses are not supported by the estimates that indicate more economic growth after an increase in energy prices.

A potential explanation of this lies in the behavior of Governments in the oil exporter countries of the MENA region. These countries have public budgets that are balanced at relatively low prices of oil. For instance, Kuwait's budget is balanced when the barrel of oil is priced at $49.1, whereas Saudi Arabia's and UAE's budgets are balanced when the barrel of oil is $83.8 and $67 respectively.[28] The excess revenues due to higher oil prices flow to the country's sovereign wealth funds which are mainly invested in the US and Europe.[29] However, when oil prices are low, these funds liquidate assets in order to support the current level of public spending. In that sense, the sovereign wealth funds play an important role in the stability of public spending and the economy when oil prices are low. Therefore, a drop in the oil price will not have its toll on the economy.[30]

[INSERT TABLE 7 HERE]

However, following increases in the oil price, additional resources will be transferred from oil importer countries to oil exporter countries. These revenues support higher levels of public spending, investments, output, and growth. The higher oil price will also induce more

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[28] Source: Fitch, High Mark Capital, Capital, IWF, WSJ.

[29] These funds are owned by the government. Their time horizon is multigenerational and their objective is to grow and to pass the benefits of oil revenues through to future generations.

[30] Note that domestic oil prices are controlled and hence, the adjustment effect in minor.

public and private investments in the oil and the gas sectors due to the now higher expected returns. As domestic oil prices are not changing, there will be hardly any sectoral allocation adjustments in either labor, capital or even investment as a response to the increase in global oil prices.[31] Moreover, the high prices of oil will reduce uncertainty regarding the future of government revenues, spending, economic growth, and jobs. This, in turn, stimulates more private investment and spending. Therefore, increases in oil prices strongly influence output expansion in MENA countries.[32]

As mentioned previously, an important feature of the non-linear ARDL model is the possibility to observe the adjustment paths of the real industrial production due to positive and negative shocks in the real oil price. The adjustment paths capture the dynamics of the real industrial production as it moves from its initial equilibrium to the new one following a shock to the oil price. Figure 3 depicts how the cumulative dynamic multipliers of output are changing across time following positive and negative oil shocks.

The figure contains three lines and a band. The green and red lines shows adjustment to positive and negative shocks respectively. The blue middle line is the line that shows asymmetry and it offsets the impact on the equilibrium of similar positive and negative shocks. The location of the line should be around zero if the real output responds symmetrically to changes in the oil prices. Finally, the cloud band is the 90% confidence interval which is generated by bootstrapping the sample positive and negative cumulative sums of the real oil prices, and then estimating the dynamic multiplier and offsetting it at various horizons.

[31] The only potential adjustment is the reallocation of resources into the energy sector as it is now more profitable due to higher oil prices.

[32] Note that in the literature, there is a strong evidence that falls in oil prices are unlikely to initiate an expansion, while rises are likely to trigger recessions. See Kilian and Vigfusson (2011), Kilian (2008), Hamilton (2009), Edelstein and Kilian (2009) among many others.

In Figure 3, the positive (negative) oil price shock has a positive (negative) impact on the output of oil exporters and Egypt, but a negative impact only on Tunisia. Moreover, Figure 3 clearly shows that the influence of increases in the oil price on the industrial output is higher than the influence of oil price decreases. The blue line and its confidence interval are always above zero and for all countries. The degree of asymmetry is similar across oil exporters but it is slight for Egypt. In Tunisia, there is a slight asymmetry in the opposite direction.

Figure 3 also shows that the adjustment to a drop in the oil price in the oil exporter countries takes a longer time than the adjustment in oil importers: around 60 months, 40 months, and 20 months are needed for the industrial output to reach its new equilibrium in Saudi Arabia, Kuwait, and the UAE respectively. However, equilibrium is attained within one year in Egypt and Tunisia.

The slow adjustments may indicate that oil exporters are rich and own large financial reserves that are tapped when necessary in order to support and stabilize their economies in the face oil price decreases. The poor economies of Egypt and Tunisia have little resources and then absorb shocks quickly by reducing their industrial outputs.

The upshot here is that output is more stable and its adjustments are slower in the oil exporter countries of the MENA region. Moreover, the output increases at a slower pace when oil prices increase, but it drops at a relatively faster rate when oil prices decrease.

[INSERT FIGURE 3 HERE]

6. Robustness analysis

To check if results stands another specification, we estimate the VAR model of Kilian and Vigfusson (2011a, b) which is a structural model that uses 12 monthly lags:[33]

$$OP_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{11,i}\, OP_{t-i} + \sum_{i=1}^{p} \alpha_{12,i}\, IP_{t-i} + \varepsilon_{1,t} \quad (9)$$

$$IP_t = \alpha_{20} + \sum_{i=0}^{p} \alpha_{21,i}\, OP_{t-i} + \sum_{i=1}^{p} \alpha_{22,i}\, IP_{t-i} + \sum_{i=0}^{p} \gamma_{21,i}\, OP_{t-i}^{+} + \varepsilon_{2,t} \quad (10)$$

where OP_t^+ is the maximum real price of oil in the previous 12 months i.e., $OP_t^+ = \max(OP_t^+, 0)$; $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are serially uncorrelated disturbances with zero mean. Asymmetry is investigated by testing the null $H_0: \gamma_{21,i} = \gamma_{12,i} = 0$ for all i using a Wald test that is asymptotically distributed as χ_p^2.

Table 8 displays the slope-based test results using 12 lags. The Wald test rejects the null above at the 0.01% significance level in all countries. Thus, we conclude asymmetry under this model as well.

[INSERT TABLE 8 HERE]

To see if the paths of the response of the real output to oil price changes are symmetric, we use a test statistic that is based on 10,000 bootstrap simulations of impulse response functions of Equations 9 and 10. The null hypothesis is written as

$$H_0 : IRF_{IP}(h, \delta) = -IRF_{IP}(h, -\delta)$$

where the IRF_{IP} is the impulse responses of output to oil shocks δ that are functions of the horizon h. Under the null, a Wald test statistics has an asymptotic distribution of $\chi_p^2(H+1)$.

Table 9 reports the p-values of the test of symmetry from two months to one year. The test is conducted for one and two standard error $\hat{\sigma}$ shocks in the oil price. The table shows that responses are asymmetric particularly for large shocks. This result is significant and uniform

[33] In the literature, there is no guide to the number of lags that are adequate to capture the dynamics in the oil-output VAR relationship. However, many studies have gone back one year (Hamilton and Herrera, 2004; Jiménez-Rodríguez and Sánchez, 2005; Herrera et al. 2011; Herrera et al. 2015; Kilian and Vigfusson, 2011a, b).

across all countries. However, when the shock size is relatively small, the null of symmetry is only rejected for short horizons. Over longer horizons that extends beyond 8 months, responses in output to positive and negative one standard error shocks in oil are likely to be equivalent. The exception is Saudi Arabia which shows pronounced asymmetry for shocks of various magnitude in the oil price and over all horizons.

The graphical representation of impulse-responses for various positive shock sizes is displayed in Figure 4.

[INSERT TABLE 9 HERE]

[INSERT FIGURE 4 HERE]

7. Conclusion and Policy Implications

In this research, we provide recent evidence on the asymmetric influence of oil price changes on the industrial output of six MENA countries. The results that we obtain are interesting and intuitive. First, we find that growth in MENA countries is linked to oil in the sense that it benefits from higher oil prices and it gets hurt by a fall in the oil market. Moreover, there is pronounced short- and long-term asymmetries in the influence of oil on output. In particular, the output is faster to respond to increases in oil prices than to decreases. The long-term influence to a rise in the oil price is also higher although it is realized over a longer period.

The findings in this paper are important for politicians and policy makers in the MENA region. First, the danger to economic growth and employment in the MENA region lies when the oil price falls. The first shock will hit public revenues and then it spreads across the economy. Therefore, these countries should set up policies that hedge against drops in the oil market in order to moderate its effects on the domestic economy. For instance, governments in the MENA region may buy insurance against oil price falls when it is expected. Similarly, businesses should adopt a risk management strategy against energy price fluctuations.

Furthermore, attempts to engage in long term contracts to supply oil when prices are relatively high may also help stabilize the MENA economies.

The idea of diversifying government revenues away from oil seems to be crucial. This can be done by diversifying the economy itself and by restructuring the whole of the tax regime in order to fit for that purpose.

The establishment of sovereign wealth funds is an intelligent idea that can be also used to promote a stable macroeconomic environment against volatile energy markets. Therefore, these funds should be encouraged and mandated to support the economy against oil price volatility. These funds should target allocations that are weakly correlated with energy markets.

In the oil importer countries of the MENA region, hedging the fluctuation of oil prices and increasing dependence on clean energy sources is paramount to protect government budgets and to stabilize and grow the economies.

Appendix A

[INSERT TABLE A1 HERE]

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Table 1: Descriptive statistics of level variables

	Mean	Std. dev.	Skewness	Kurtosis	Jarque-Bera
Real industrial production (IP)					
Egypt	10.993	0.084	1.304	3.365	26.015***
Tunisia	9.343	0.036	0.111	2.800	0.470
UAE	10.809	0.043	-0.301	2.198	4.442
Saudi Arabia	11.102	0.038	0.632	2.814	8.093**
Kuwait	9.399	0.039	-0.502	2.214	5.957*
Qatar	9.964	0.043	-0.688	2.301	9.333***
Real oil prices (OP)					
Egypt	3.012	0.153	-1.088	2.999	18.171***
Tunisia	2.197	0.121	-0.666	2.643	10.231***
UAE	2.470	0.165	-0.384	1.915	9.292***
Saudi Arabia	2.488	0.166	-0.456	2.320	7.495**
Kuwait	1.357	0.151	-0.624	1.982	11.673***
Qatar	2.466	0.160	-0.922	2.498	14.307***
Real inflation rate (INF)					
Egypt	0.010	0.011	0.653	4.326	13.272***
Tunisia	0.004	0.003	0.083	2.887	0.217
UAE	0.002	0.004	1.623	10.206	327.943***
Saudi Arabia	0.003	0.005	3.116	20.379	1974.129***
Kuwait	0.002	0.003	1.042	4.142	25.401***
Qatar	0.001	0.004	-0.529	4.914	22.530***
Real interest rate (R)					
Egypt	0.079	0.032	1.475	4.098	38.003***
Tunisia	0.042	0.006	-0.221	3.577	2.840
UAE	0.047	0.006	0.063	3.772	3.213
Saudi Arabia	0.007	0.014	1.778	6.233	133.731***
Kuwait	0.046	0.005	0.241	3.624	2.801
Qatar	0.053	0.012	0.918	3.036	15.890***

Note: The values in parentheses are p-values.
∗∗∗ $p < 0.01$.
∗∗ $p < 0.05$.
∗ $p < 0.1$.

Table 2: Unit root tests with constant and linear trend, t-stat. (ADF, automatic lag length, max = 12)

	Level		First Difference		Second Difference	
Real industrial production (IP)						
Egypt	-2.763	(0.214)	-8.538**	(0.000)		
Tunisia	-4.908***	(0.000)	-4.491***	(0.002)		
UAE	-2.885	(0.171)	-18.151***	(0.000)		
Saudi Arabia	-2.505	(0.325)	-2.786	(0.205)	-8.198***	(0.000)
Kuwait	-1.695	(0.744)	-2.291	(0.433)	-4.835***	(0.001)
Qatar	1.926	(0.999)	-3.367**	(0.015)		
Real oil prices (OP)						
Egypt	-1.989	(0.598)	-6.851***	(0.000)		
Tunisia	-2.583	(0.288)	-8.370***	(0.000)		
UAE	-2.549	(0.304)	-7.424***	(0.000)		
Saudi Arabia	-3.098	(0.110)	-8.000***	(0.000)		
Kuwait	-2.134	(0.520)	-7.875***	(0.000)		
Qatar	-3.242*	(0.081)	-8.481***	(0.000)		
Real inflation rate (INF)						
Egypt	-7.061***	(0.000)	-7.762***	(0.000)		
Tunisia	-3.551**	(0.038)	-11.536***	(0.000)		
UAE	-8.291***	(0.000)	-7.937***	(0.000)		
Saudi Arabia	-10.773***	(0.000)	-9.723***	(0.000)		
Kuwait	-5.759***	(0.000)	-7.113***	(0.000)		
Qatar	-8.647***	(0.000)	-9.944***	(0.000)		
Real interest rate (R)						
Egypt	-2.791	(0.204)	-11.904***	(0.000)		
Tunisia	-1.967	(0.613)	-4.094***	(0.008)		
UAE	-6.343***	(0.000)	-7.459***	(0.000)		
Saudi Arabia	-3.654**	(0.029)	-14.001***	(0.000)		
Kuwait	-2.362	(0.396)	-5.758***	(0.000)		
Qatar	-1.665	(0.760)	-12.985***	(0.000)		

Notes: H0: ln(variable) has a unit root. Critical values are -4.063, -3.460, and 3.156 for 1%, 5% and 10% level. The values in parentheses are p-values.
∗∗∗ $p < 0.01$.
∗∗ $p < 0.05$.
∗ $p < 0.1$.

Table 3: Lee-Strazicich two-break unit-root test

	T-statistic	Selected lag	Time break 1	Time break 2	DU_1	DU_2	DT_1	DT_2
Egypt								
Level								
IP	-4.570	5	2012:10	2013:7	-0.200 (-2.275)	0.082 (0.877)	-0.200 (5.660)	-0.145* (-1.729)
OP	-5.749*	8	2010:10	2012:10	-0.097*** (-5.345)	0.138*** (5.988)	0.036 (0.886)	-0.060* (-1.339)
INF	-6.845**	2	2015:4	2017:7	-0.020*** (-5.419)	-0.009** (-2.546)	0.022** (2.225)	-0.011 (-1.149)
R	-6.190*	8	2015:7	2017:3	0.000 (0.071)	0.027*** (3.993)	0.018 (1.590)	-0.015 (-1.244)
First Difference								
ΔIP	-12.929***	7	2012:10	2013:5	-0.271*** (-4.944)	0.295*** (4.011)	0.564*** (7.366)	-0.141*** (-3.763)
ΔOP	-7.144***	2	2011:2	2013:4	0.058*** (4.522)	0.011 (0.819)	-0.128** (-2.786)	-0.097** (-2.164)
ΔINF	-9.842***	1	2013:8	2017:5	0.017*** (5.464)	-0.053*** (-8.101)	-0.025** (-2.091)	0.076*** (5.808)
ΔR	-10.331***	1	2013:3	2016:11	-0.034*** (-8.060)	0.062*** (9.122)	0.059*** (4.656)	-0.068*** (-5.339)
Tunisia								
Level								
IP	-4.409	6	2010:1	2015:12	-0.029 (-1.812)	0.032 (1.295)	0.063** (2.957)	-0.034* (-1.703)
OP	-5.317*	2	2008:6	2014:1	0.019** (2.071)	-0.055*** (-4.380)	-0.010 (-0.298)	-0.050 (-1.427)
INF	-6.575***	6	2010:10	2014:7	-0.005*** (-5.267)	0.007*** (6.193)	0.008*** (3.206)	-0.011*** (-4.030)
R	-4.850	6	2012:8	2015:10	0.003** (3.437)	-0.007*** (-4.164)	-0.006* (1.691)	0.010** (2.715)
First Difference								
ΔIP	-9.212***	11	2008:11	2014:9	0.091*** (9.017)	-0.100*** (-9.586)	-0.120*** (-5.541)	0.109*** (5.236)
ΔOP	-7.545***	2	2008:1	2014:3	-0.072*** (-4.697)	0.049*** (5.432)	0.250*** (7.301)	-0.090** (-2.437)
ΔINF	-11.916***	4	2014:11	2015:6	-0.005*** (-4.442)	0.011*** (7.423)	0.006** (2.143)	-0.005 (-1.919)
ΔR	-8.441***	5	2013:8	2015:9	0.007*** (6.103)	-0.023*** (-8.544)	-0.014** (-3.751)	0.028*** (6.451)
UAE								
Level								
IP	-5.336*	5	2008:8	2012:5	0.002 (0.467)	-0.015*** (-3.201)	0.015 (0.748)	0.056** (2.642)
OP	-5.505*	2	2008:3	2013:10	0.038*** (3.637)	-0.062*** (-4.760)	-0.007 (-0.198)	-0.049* (-1.414)
INF	-7.586***	5	2009:1	2015:9	0.008*** (4.989)	-0.005*** (-5.176)	-0.015*** (-3.675)	-0.001 (0.358)
R	-5.981**	7	2011:3	2016:10	-0.004*** (-4.127)	0.010*** (5.608)	-0.001 (-0.258)	-0.015*** (-3.609)
First Difference								
ΔIP	-11.047***	1	2007:12	2009:10	-0.120*** (-8.829)	0.037*** (5.888)	0.155*** (6.462)	-0.004 (-0.182)
ΔOP	-7.388***	5	2008:1	2015:6	0.104*** (5.348)	0.023** (2.579)	-0.116** (-2.790)	0.022 (0.611)
ΔINF	-9.798***	7	2015:5	2016:4	-0.017*** (8.705)	0.034*** (9.946)	0.023*** (4.581)	-0.038*** (-6.772)
ΔR	-10.050***	5	2015:11	2016:8	-0.025*** (-9.080)	0.027*** (8.772)	0.032*** (5.777)	-0.035*** (-6.496)

(*continued on next page*)

Table 3: (continued)

	T-statistic	Selected lag	Time break 1	Time break 2	DU_1	DU_2	DT_1	DT_2
Saudi Arabia								
Level								
IP	-4.866	5	2010:1	2012:9	0.022** (2.552)	-0.033** (-3.112)	-0.065* (-1.940)	0.028 (1.021)
OP	-5.378*	2	2014:10	2015:8	-0.046*** (-3.845)	0.029** (2.358)	0.009 (0.262)	0.061* (1.781)
INF	-9.791***	1	2008:1	2009:6	0.001 (0.566)	0.000 (0.178)	-0.003 (-0.702)	0.005 (1.098)
R	-5.789**	5	2008:1	2009:4	-0.014*** (-4.299)	-0.008** (-3.400)	0.008 (1.404)	0.007 (1.363)
First Difference								
ΔIP	-9.035***	9	2012:12	2015:1	0.063*** (7.915)	-0.128*** (-8.820)	-0.100*** (-4.991)	0.184*** (8.176)
ΔOP	-8.091***	2	2008:7	2009:2	-0.126*** (-5.182)	0.055*** (3.281)	0.086** (2.191)	-0.075** (-2.137)
ΔINF	-14.025***	1	2008:2	2010:5	0.012*** (5.682)	-0.016*** (-9.526)	-0.014** (-2.323)	0.022*** (3.774)
ΔR	-13.632***	1	2010:6	2014:8	-0.019** (-9.931)	0.013*** (8.538)	0.024*** (3.967)	-0.012** (-1.996)
Kuwait								
Level								
IP	-4.588	8	2008:6	2010:11	0.027*** (3.944)	-0.030*** (-4.448)	-0.046*** (-3.125)	0.037** (2.255)
OP	-4.990	2	2012:3	2013:10	-0.119*** (-4.027)	0.054** (2.456)	0.048 (1.438)	-0.008 (-0.305)
INF	-8.219***	7	2010:7	2016:5	0.004*** (3.898)	-0.012*** (-7.933)	-0.011*** (-4.122)	0.017*** (5.751)
R	-5.458	7	2011:1	2013:4	0.004*** (3.252)	0.006*** (4.873)	0.002 (0.617)	-0.013*** (-4.510)
First Difference								
ΔIP	-9.507***	11	2009:4	2010:10	0.056*** (9.170)	-0.078*** (-10.251)	-0.114*** (-8.699)	0.087*** (5.856)
ΔOP	-8.067***	2	2012:6	2013:5	-0.073*** (-5.287)	0.010*** (2.936)	0.128*** (3.488)	-0.016** (-2.548)
ΔINF	-12.636***	7	2012:5	2016:7	-0.028*** (-11.511)	0.017*** (8.518)	0.033*** (8.841)	-0.009** (-2.644)
ΔR	-11.448***	7	2012:10	2013:12	0.021*** (10.197)	-0.004*** (-3.052)	-0.029*** (7.920)	-0.002 (-0.587)
Qatar								
Level								
IP	-6.970	5	2011:11	2015:1	-0.0126*** (-3.163)	0.0201*** (4.065)	0.011 (0.743)	-0.071*** (-4.295)
OP	-4.002	1	2014:12	2015:9	-0.048** (-2.951)	-0.015 (-1.087)	-0.079** (-2.224)	0.006 (0.191)
INF	-9.744***	2	2009:11	2010:2	0.001 (0.632)	-0.009*** (-3.106)	-0.004 (-0.827)	0.006* (1.703)
R	-5.458	2	2010:11	2017:5	-0.007*** (-4.411)	0.014*** (5.276)	0.004 (1.008)	-0.018*** (-3.825)
First Difference								
ΔIP	-11.027***	5	2010:8	2015:1	-0.163*** (-8.893)	-0.074*** (-6.511)	0.052** (2.447)	0.255*** (10.668)
ΔOP	-8.569***	2	2009:12	2010:7	-0.055 (-3.037)	0.021 (1.516)	0.055 (1.468)	-0.015 (-0.428)
ΔINF	-13.351***	1	2010:5	2016:4	-0.014*** (-8.546)	-0.012*** (-8.841)	0.017*** (3.766)	0.020*** (4.517)
ΔR	-13.918***	1	2010:9	2011:7	0.014*** (6.491)	0.017*** (8.314)	-0.015*** (-3.111)	-0.026*** (-5.514)

Notes: H0: ln (Variable) has a unit root. Critical values are -5.847, -5.332, and -5.064 for 1%, 5% and 10% level. The number of lags was set at maximum 12. The values in parentheses are t-statistics.
∗∗∗ $p < 0.01$.
∗∗ $p < 0.05$.
∗ $p < 0.1$.

Table 4: Diks–Panchenko Granger causality test

	$OP \neq> IP$		$IP \neq> OP$	
Country	Test Statistic		Test Statistic	
Egypt	1.749**	(0.040)	1.119	(0.131)
Tunisia	2.322**	(0.037)	0.642	(0.260)
UAE	2.602**	(0.024)	1.194	(0.116)
Saudi Arabia	3.312**	(0.014)	1.251	(0.105)
Kuwait	2.467**	(0.032)	1.170	(0.120)
Qatar	2.154	(0.015)	0.994	(0.160)

Note: The symbol "≠>" implies no Granger-causality. The optimal Embedding dimension = 2. The series are in first differences. The Panchenko's C++ code is used to get the test statistics and the p-values. Numbers in brackets are the associated p-values.
∗∗∗ p < 0.01.
∗∗ p < 0.05.
∗ p < 0.1.

Table 5: Hatemi-J asymmetric Granger causality test

	Hypothesis	Wald Test Statistic	Bootstrap Critical Values		
			1%	5%	10%
Egypt	$OP^+ \neq> IP^+$	2.073*	12.743	4.052	2.015
	$OP^- \neq> IP^-$	6.043**	13.845	2.597	1.154
	$OP^+ \neq> IP^-$	1.276	7.065	2.702	1.698
	$OP^- \neq> IP^+$	1.034	8.741	3.329	1.942
Tunisia	$OP^+ \neq> IP^+$	2.633	7.408	3.937	2.704
	$OP^- \neq> IP^-$	1.998	5.924	3.599	2.448
	$OP^+ \neq> IP^-$	4.039**	6.502	3.782	2.647
	$OP^- \neq> IP^+$	7.346***	7.204	3.654	2.710
UAE	$OP^+ \neq> IP^+$	4.376**	6.765	4.041	2.918
	$OP^- \neq> IP^-$	6.622***	6.438	3.921	2.655
	$OP^+ \neq> IP^-$	1.067	6.912	4.069	2.569
	$OP^- \neq> IP^+$	1.887	7.321	4.451	3.097
Saudi Arabia	$OP^+ \neq> IP^+$	6.507***	6.425	3.947	2.658
	$OP^- \neq> IP^-$	8.669***	7.534	4.053	2.839
	$OP^+ \neq> IP^-$	3.591**	6.234	3.476	2.541
	$OP^- \neq> IP^+$	1.608	6.935	3.622	2.672
Kuwait	$OP^+ \neq> IP^+$	9.531***	7.377	3.887	2.612
	$OP^- \neq> IP^-$	7.089***	6.913	3.091	2.213
	$OP^+ \neq> IP^-$	0.166	7.118	3.807	2.867
	$OP^- \neq> IP^+$	3.860*	7.191	4.111	2.998
Qatar	$OP^+ \neq> IP^+$	7.330***	6.765	3.562	2.661
	$OP^- \neq> IP^-$	8.098***	7.536	4.365	2.975
	$OP^+ \neq> IP^-$	1.330	6.765	3.562	2.661
	$OP^- \neq> IP^+$	0.470	8.503	4.178	2.702

Note: The vectors (IP^+, OP^+) and (IP^-, OP^-) are the cumulative positive and negative shocks respectively. $OP \neq> IP$ indicates that real oil prices do not cause real industrial production. The max lag length set at 4 and the optimal one is selected based on minimizing the information criterion suggested by Hatemi-J (2003). We estimate the table using Hatemi-J's (2012) GAUSS code for asymmetric causality.
∗∗∗ p < 0.01.
∗∗ p < 0.05.
∗ p < 0.1.

Table 6: NARDL estimation results for pass-through of oil prices (OP) to industrial production (IP)

	Egypt		Tunisia		UAE		Saudi Arabia		Kuwait		Qatar	
IP_{t-1}	-0.684***	(0.000)	-0.311**	(0.042)	-0.311***	(0.008)	-0.264***	(0.003)	-0.173**	(0.034)	-0.708***	(0.000)
OP^{+}_{t-1}	0.273**	(0.022)	-0.015*	(0.081)	0.132***	(0.003)	0.121***	(0.002)	0.056***	(0.008)	0.0619	(0.432)
OP^{-}_{t-1}	-0.100*	(0.066)	0.035	(0.312)	-0.076***	(0.009)	-0.064**	(0.033)	-0.075**	(0.030)	-0.010***	(0.002)
INF_{t-1}	1.288**	(0.025)	1.089**	(0.040)	-2.412*	(0.061)	1.288**	(0.025)	1.468*	(0.072)	0.009	(0.991)
R_{t-1}	-0.781***	(0.004)	-0.172*	(0.071)	-2.384***	(0.009)	-0.781***	(0.004)	-0.317*	(0.061)	-0.584*	(0.068)
ΔIP_{t-1}	-0.055	(0.665)	-0.1422	(0.373)	-0.487 ***	(0.001)	-0.152***	(0.000)	-0.173**	(0.034)	-0.228**	(0.027)
ΔIP_{t-3}									-0.330***	(0.008)		
ΔIP_{t-7}			-0.313***	(0.010)	-0.298***	(0.000)						
ΔIP_{t-9}							0.199**	(0.050)				
ΔIP_{t-10}											-0.364***	(0.000)
ΔIP_{t-11}	0.071**	(0.047)			-0.384***	(0.000)			-0.411***	(0.001)		
ΔOP^{+}_{t}	0.341**	(0.048)	-0.079**	(0.049)	0.391***	(0.004)	0.803***	(0.001)	0.187**	(0.011)	0.075*	(0.054)
ΔOP^{+}_{t-2}	0.309*	(0.054)					0.132**	(0.030)	0.111**	(0.033)	0.135**	(0.018)
ΔOP^{+}_{t-3}			-0.094**	(0.041)			0.299*	(0.069)				
ΔOP^{-}_{t}	-0.135**	(0.043)	0.003*	(0.096)	-0.093**	(0.040)	-0.0623**	(0.023)	-0.133***	(0.005)	-0.088**	(0.032)
ΔOP^{-}_{t-2}											-0.078**	(0.040)
ΔOP^{-}_{t-4}	-0.044*	(0.067)	0.177*	(0.097)	-0.0232	(0.082)	-0.130***	(0.001)	-0.083***	(0.002)		
ΔINF_{t-1}	2.627***	(0.000)	4.258**	(0.015)	1.369*	(0.054)	2.627***	(0.000)	1.130*	(0.072)	-0.212	(0.790)
ΔR_{t-1}	-1.526***	(0.001)	2.548	(0.115)	-3.189***	(0.004)	-2.526***	(0.001)	-1.496***	(0.009)	1.081	(0.408)
Constant	7.677***	(0.000)	2.890**	(0.043)	2.894***	(0.011)	4.067***	(0.000)	1.611**	(0.034)	3.329***	(0.007)
$L_{OP^{+}}$	0.399**	(0.024)	-0.383**	(0.017)	0.425***	(0.000)	0.398***	(0.002)	0.323***	(0.007)	0.008	(0.810)
$L_{OP^{-}}$	-0.147**	(0.013)	0.089	(0.385)	-0.245***	(0.000)	-0.213**	(0.040)	-0.147**	(0.046)	-0.102***	(0.000)
R^2	0.84		0.61		0.637		0.739		0.876		0.808	
R^2_{adj}	0.69		0.43		0.511		0.562		0.658		0.647	
χ^2_{SC}	29.89	(0.790)	37.05	(0.603)	38.43	(0.541)	21.42	(0.980)	41.80	(0.233)	51.33*	(0.089)
χ^2_{H}	0.21	(0.642)	0.23	(0.627)	0.521	(0.470)	2.714	(0.299)	1.269	(0.252)	0.549	(0.599)
χ^2_{FF}	2.27	(0.103)	1.12	(0.347)	0.653	(0.583)	1.17	(0.509)	1.231	(0.308)	1.735	(0.180)
t_{BDM}	-4.209		-3.787		-4.783		-5. 784		-2.159		-4.840	
F_{PSS}	4.074		3.632		11.260		8.587		2.164		7.944	

Note: This table reports the estimation results of the best-suited NARDL specifications for the pairs comprised of oil prices and industrial production. $L_{OP^{+}}$ and $L_{OP^{-}}$ are long-run coefficients associated with positive and negative changes of oil prices, respectively. t_{BDM} is the Banerjee et al. (1998) t-statistic while F_{PSS} denotes the Pesaran et al. (2001) F-statistic for bounds test respectively. Following Shin et al. (2014), the preferred model is chosen by starting with max p = max q = 12 and then dropping all insignificant regressors. The 5% critical values of t_{BDM}t are -3.53 and -3.22 for k = 2 and k = 1, respectively, while the equivalent values for F_{PSS} are 4.85 and 5.73. Numbers in brackets are the associated p-values.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

Table 7: Results of short- and long-run symmetry tests in multivariate setting

Country	W_{LR}		W_{SR}	
Egypt	11.59***	(0.001)	6.83**	(0.012)
Tunisia	11.65***	(0.001)	0.044	(0.835)
UAE	75.67***	(0.000)	11.98***	(0.001)
Saudi Arabia	32.33***	(0.000)	16.92***	(0.000)
Kuwait	8.695**	(0.005)	3.913*	(0.074)
Qatar	57.24***	(0.000)	2.0435	(0.102)

Notes: The table reports the results of the short- and long-run symmetry tests for the effect of oil prices on the industrial production. W_{SR} denotes the Wald test for the short-run symmetry, while W_{LR} corresponds to the Wald test for long-run symmetry. Numbers in brackets are the associated p-values.
∗∗∗ p < 0.01.
∗∗ p < 0.05.
∗ p < 0.1.

Table 8: Wald Test for asymmetries

Country	χ_p^2	p-values
Egypt	217.579***	(0.000)
Tunisia	157.662***	(0.000)
UAE	626.820***	(0.000)
Saudi Arabia	1455.985***	(0.000)
Kuwait	224.238***	(0.000)
Qatar	928.574***	(0.000)

Notes: this table report the Wald test and its p-values with the null hypothesis of joint significant, that is $\gamma_{21,i} = \gamma_{12,i} = 0$ for all i.
∗∗∗ p < 0.01.
∗∗ p < 0.05.
∗ p < 0.1.

Table 9: Testing the symmetry of the response, $H_0 : IRF_{IP}(h, \delta) = -IRF_{IP}(h, -\delta)$ for $h =, 0, 1, \ldots, H$

	Egypt		Tunisia		UAE		Saudi Arabia		Kuwait		Qatar	
h	$\hat{\sigma}$	$2\hat{\sigma}$	$\hat{\sigma}$	$2\hat{\sigma}$	$\hat{\sigma}$	$2\hat{\sigma}$	$\hat{\sigma}$	$2\hat{\sigma}$	$\hat{\sigma}$	$2\hat{\sigma}$	$\hat{\sigma}$	$2\hat{\sigma}$
0	0.004***	0.001***	0.946	0.935	0.003***	0.000***	0.016**	0.008***	0.381	0.502	0.399	0.497
2	0.009***	0.000***	0.091*	0.033**	0.027**	0.001***	0.062*	0.034**	0.018**	0.001***	0.001***	0.000***
4	0.030**	0.001***	0.281	0.066*	0.082*	0.003***	0.002***	0.027**	0.061*	0.006***	0.006***	0.000***
8	0.079*	0.001***	0.582	0.020**	0.148	0.000***	0.030**	0.095*	0.085*	0.000***	0.033**	0.001***
10	0.145	0.003***	0.740	0.023**	0.288	0.002***	0.004***	0.018**	0.278	0.001***	0.052*	0.000***
12	0.178	0.004***	0.788	0.027**	0.532	0.003***	0.100*	0.023**	0.339	0.001***	0.074*	0.000***

Notes: The table shows the p-vales of testing the symmetric impulse responses of industrial production to positive and negative shocks in real oil price of one standard deviation shocks, δ=σ̂ and two standard deviation shocks, δ=2σ̂). p−values are based on the χ^2_{H+1}. The estimated impulse response functions computed using 10,000 bootstrap simulations.
∗∗∗ p < 0.01.
∗∗ p < 0.05.
∗ p < 0.1.

Table A1: Unit root tests for asymmetric components

		ADF with constant and linear trend				Lee-Strazicich two-break unit-root test	
		Level		First Difference		Level	First Difference
Real industrial production (IP)							
Egypt	IP_t^+	-1.866	(0.663)	-10.447***	(0.000)	-7.011***	-17.167***
	IP_t^-	-4.031**	(0.010)	-10.995***	(0.000)	-5.059	-9.203***
Tunisia	IP_t^+	-1.057	(0.931)	-14.083***	(0.000)	-6.062**	-14.020***
	IP_t^-	-1.310	(0.880)	-12.542***	(0.000)	-5.633**	-9.616***
UAE	IP_t^+	0.526	(0.999)	-14.687***	(0.000)	-6.722***	-9.310***
	IP_t^-	0.200	(0.997)	-14.310***	(0.000)	-4.789	-11.067***
Saudi Arabia	IP_t^+	-1.724	(0.734)	-9.594***	(0.000)	-6.028***	-10.040***
	IP_t^-	-1.606	(0.785)	-10.698***	(0.000)	-3.844	-8.375***
Kuwait	IP_t^+	-1.447	(0.840)	-9.656***	(0.000)	-6.220**	-7.954***
	IP_t^-	0.458	(0.999)	-13.909***	(0.000)	-4.753	-7.936***
Qatar	IP_t^+	-3.019	(0.132)	-8.545***	(0.000)	-4.028	-8.620***
	IP_t^-	-1.625	(0.776)	-13.316***	(0.000)	-4.075	-7.622***
Real oil prices (OP)							
Egypt	OP_t^+	-1.259	(0.891)	-7.890***	(0.000)	-5.947*	-9.012***
	OP_t^-	-1.889	(0.651)	-6.465***	(0.000)	-5.543	-7.343***
Tunisia	OP_t^+	-1.897	(0.649)	-10.792***	(0.000)	-4.651	-8.184***
	OP_t^-	-2.448	(0.353)	-6.911***	(0.000)	-4.665	-8.284***
UAE	OP_t^+	-2.190	(0.490)	-10.189***	(0.000)	-4.670	-8.754***
	OP_t^-	-2.496	(0.329)	-6.328***	(0.000)	-4.854	-7.625***
Saudi Arabia	OP_t^+	-2.039	(0.574)	-10.705***	(0.000)	-4.998	-8.158***
	OP_t^-	-2.452	(0.351)	-6.821***	(0.000)	-4.531	-7.859***
Kuwait	OP_t^+	-1.202	(0.904)	-10.107***	(0.000)	-5.470	-8.226***
	OP_t^-	-1.908	(0.643)	-6.709***	(0.000)	-6.794**	-8.508***
Qatar	OP_t^+	-3.037	(0.126)	-10.061***	(0.000)	-4.025	-7.626***
	OP_t^-	-1.992	(0.599)	-7.173***	(0.000)	-6.416***	-8.855***

Notes: The TDICPS software developed by Hatemi-J and Mustafa (2016) was used to transform the data into cumulative partial sums for positive and negative components. H0: ln (variable) has a unit root. The optimal lags for ADF test were selected by Schwarz information criterion with a max lag length set at 12. Critical values are -4.063, -3.460, and 3.156 for 1%, 5% and 10% level. The values in parentheses are p-values. Critical values Lee-Strazicich test are -5.847, -5.332, and -5.064 for 1%, 5% and 10% level. The number of lags was set at maximum 12.

∗∗∗ $p < 0.01$.

∗∗ $p < 0.05$.

∗ $p < 0.1$.

Figure 1: Standardized real prices of oil and industrial production

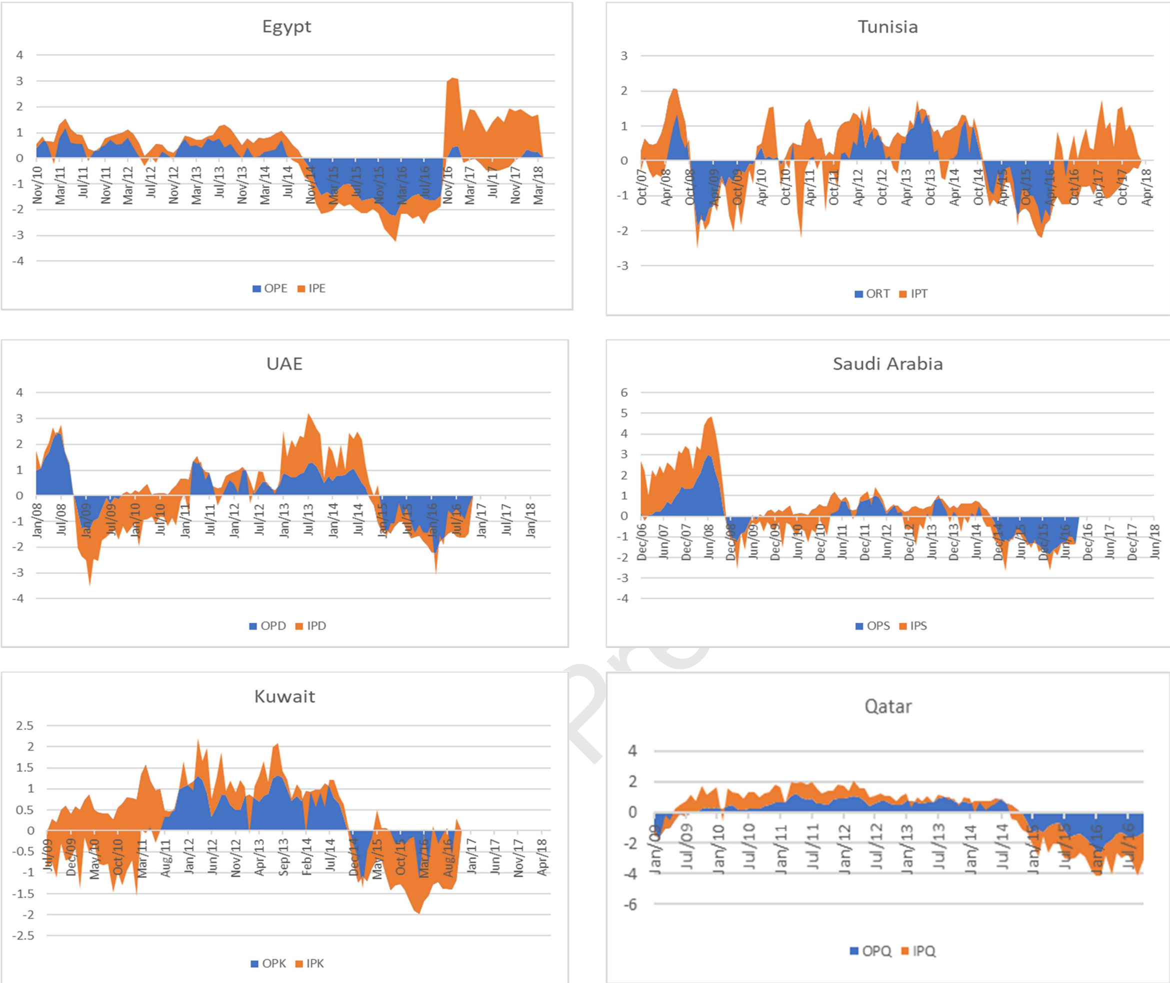


Figure 2: Partial sum processes of negative and positive changes in oil prices and industrial production

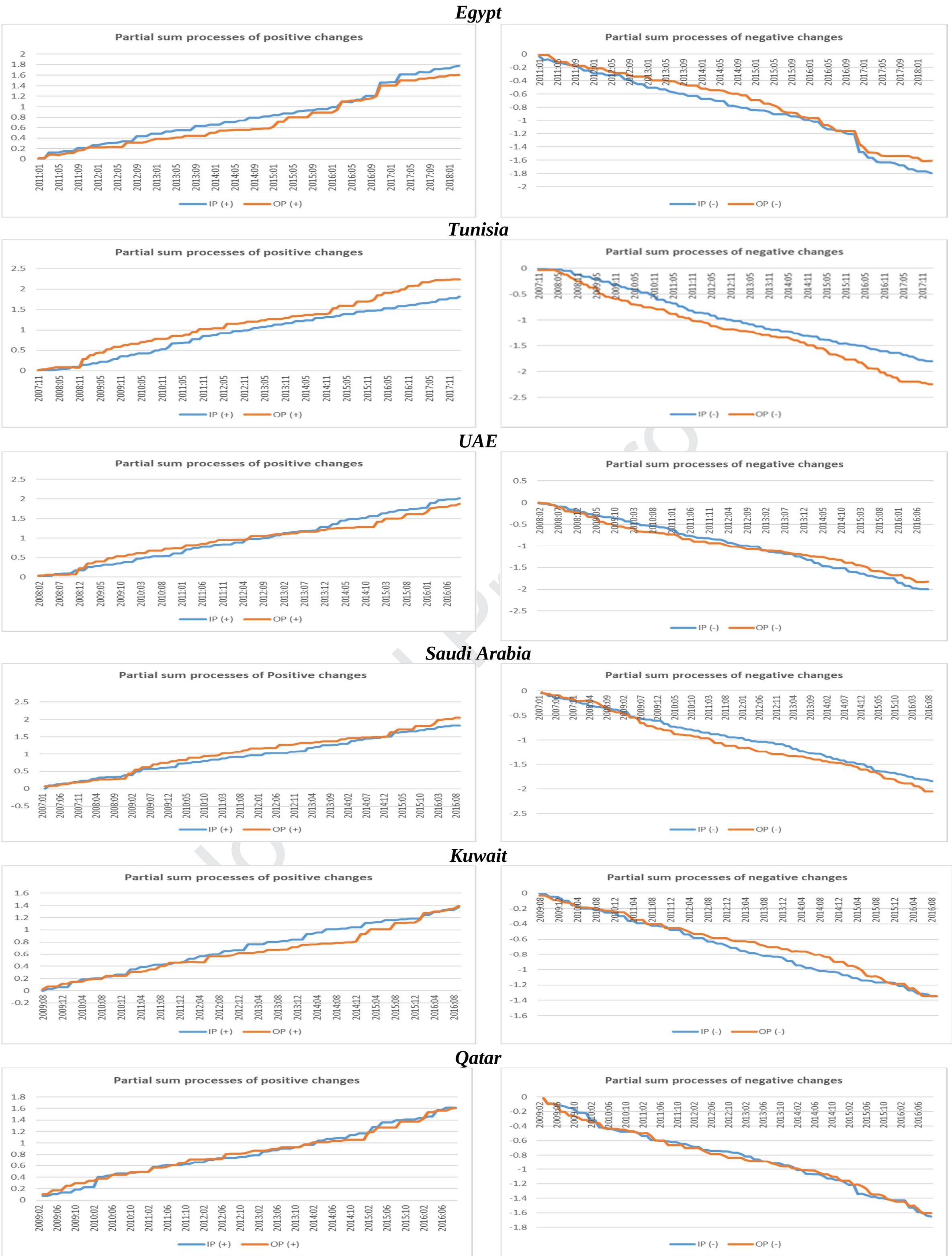
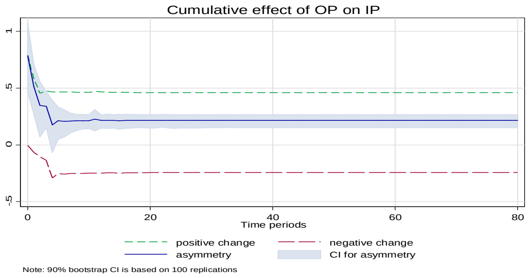
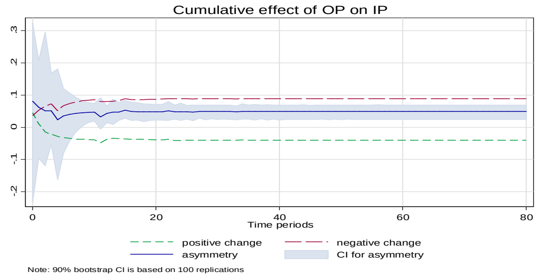


Figure 3: The oil-industrial production tradeoff dynamic multipliers

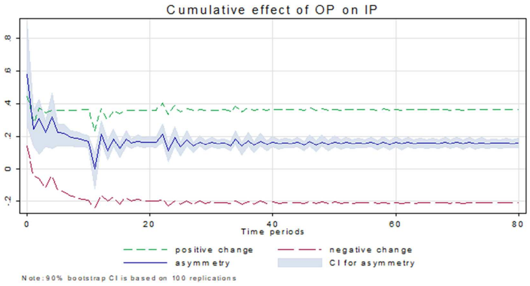
Egypt



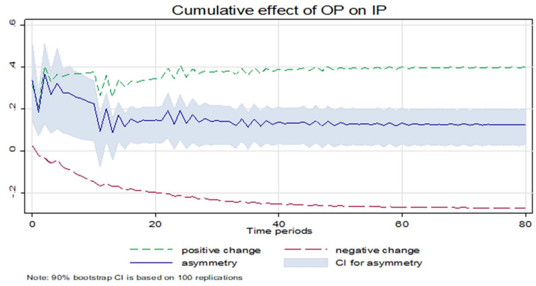
Tunisia



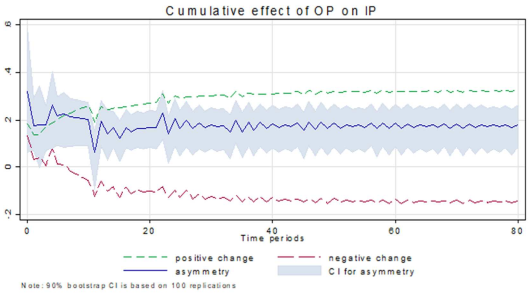
UAE



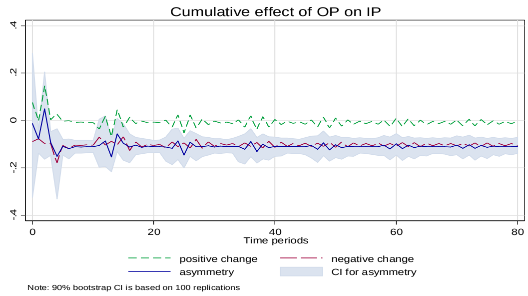
Saudi Arabia



Kuwait

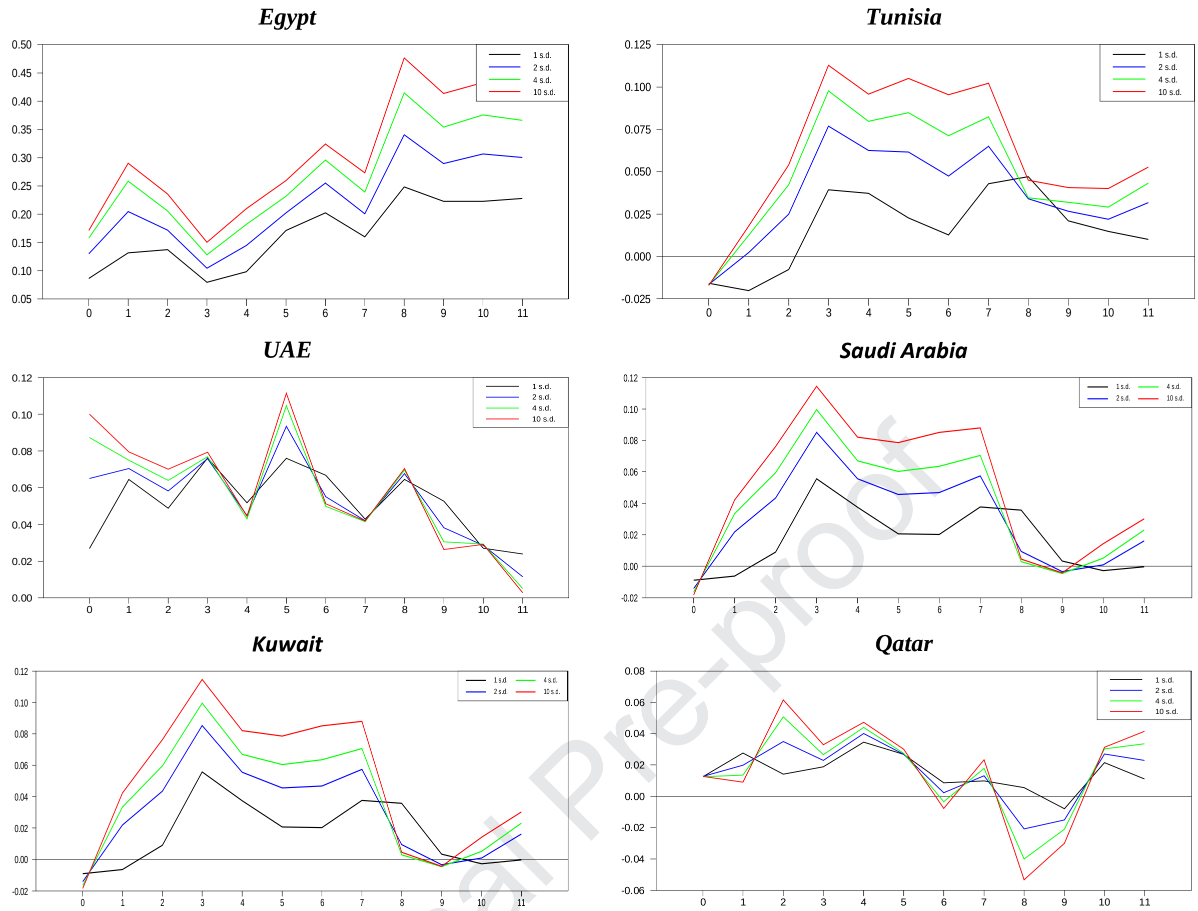


Qatar



Notes: These graphs give cumulative effects of positive and negative oil shocks on industrial production. Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the identified asymmetries in Table 4.

Figure 4: The response of industrial production to a positive oil price shock by shock size



Notes: Each plot illustrates impulse responses based on the non-linear methodology by Kilian and Vigfusson (2011a, b).

Highlights:

- Asymmetry effects of oil price changes on output in six MENA countries.
- There are short- and long-term asymmetries in the influence of oil on output.
- The output is faster to respond to increases in the oil price than it responds to decreases.
- Adopt a risk management strategy against energy price fluctuations.
- Diversify government revenue away from oil.

Conflict of Interest and Authorship Conformation Form

Please check the following as appropriate:

- All authors have participated in (a) conception and design, or analysis and interpretation of the data; (b) drafting the article or revising it critically for important intellectual content; and (c) approval of the final version.

- This manuscript has not been submitted to, nor is under review at, another journal or other publishing venue.

- The authors have no affiliation with any organization with a direct or indirect financial interest in the subject matter discussed in the manuscript

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