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Abstract

In this paper, we investigate the nature of asymmetry in the influence of oil price changes on output in five MENA countries. These are Saudi Arabia, Egypt, Kuwait, the United Arab Emirates, and Tunisia. To get more observation 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.

Keywords: Cointegration, Asymmetry, Oil, Industrial Output, MENA Countries

JEL Classifications: G15 Q43 Q47

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 expansion.[4] 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.[5] Therefore, one would expect asymmetric response of output to the same exogenous negative and positive oil shocks in the oil importing as well as the oil exporting countries.[6]

Many explanations have been provided in the literature.[7] 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. Uncertainty reduces investment spending particularly in those sectors where cash flows depend on oil.[8] Edelstein and Kilian (2009) explained 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.

A third explanation of asymmetry that is provided in the literature lies in how monetary policy reacts to increases in the oil price. Bernanke et al. (1997) indicate that while the Fed may increase rates following a hike in energy prices in order to block inflation, it does nothing when oil prices decrease. These asymmetries in the monetary policy response introduce corresponding asymmetries in output response to same changes of oil prices.

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.

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[4] See for instance, Bernanke et al. (1997); Hamilton (1988), Balke, Brown and Yucel (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), Baumeister and Hamilton (2019), and among many others.

[5] 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.

[6] Using an asymmetric version of the MIDAS model (AMIDAS), Maghyereh et al. (2018) investigated the asymmetric impact of daily oil price shocks on the quarterly real domestic product of eight developed countries during the period (1983-2016). They significant asymmetric relationship between oil price shocks and output.

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

[8] This is obvious in energy sectors but less clear in other sectors.

Therefore, in this paper, we aim to contribute to the current literature by investigating asymmetry in the response of real industrial production to oil price changes using a sample of five MENA countries. 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. Hence, studying asymmetry to oil price changes in this region is indicative of the extent the reallocation, uncertainty and monetary policy effects that accompany the changes in the oil price. Three of the countries in our sample are big exporters of oil. These are Saudi Arabia, UAE, and Kuwait. The remaining two countries produce oil, but at quantities that fall short of their domestic consumption.

The influence of oil prices on the output of oil exporting countries has been investigated by many researchers. The evidence is that the oil market performance is a decisive factor that explains the economic performance of oil-producing countries. For instance, Allegret et al. (2014) show an improved current account balance of 27 oil exporting countries when oil prices increase.[9] Similarly, Korhonen and Juurikkala (2009) record appreciations in the real exchange rate following rise in the oil price. The study by Farzanegan and Markwardt (2009) finds that Iranian output growth can be explained by the growth in the oil price. The group of oil exporting countries that are studied by El Anshasy and Bradley (2012) is found to grow during periods of high growth in the oil price. They attributed the high growth in output to higher government oil revenues and spending.

The literature on how oil price changes influence GDP in the context of MENA countries is still underdeveloped.[10] 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 crowds out private capital and investments with negative repercussions on economic growth.

Along the same lines of reasoning lies the results of the dynamic panel model of Mehrara (2008) who finds that while output growth is negatively affected by a fall in the oil market, its response to rise is weak and negligible. His sample extends over the 1965-2004 period and it contains thirteen oil exporting countries that include Kuwait, Qatar, Saudi Arabia, and the UAE. The same results for the period 1979-2009 are arrived at by the VAR model of Moshiri and Banijashem (2012) who find that spending drops after oil price falls and that this negatively influences economic growth. In their study, they also find that rises in oil prices are unlikely to be translated into sustained growth. Other similar results have been provided by Cologni and Manera (2013) who used cointegration and error correction model analysis over the period that extends from 1960 to 2010.[11]

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[9] From MENA countries his sample includes, Saudi Arabia, UAE and Kuwait among others.

[10] 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).

[11] In a recent study, Maghyereh et al. (2017) investigated the influence of oil price uncertainty on the real economic activity in Jordan and Turkey during the period 1986 –2014. Their results indicate that oil market uncertainty has a negative influence on the industrial output of Jordan and Turkey.

The recent study of Nusair (2016) stands at a stark opposite of these findings. In his study of the GCC countries, he finds that oil price increases lead to an increase in the real GDP, while oil price decreases are found to have only a limited effect on output.[12] His sample extends from 1975 to 2014 and he accounts for non-linearity and asymmetry in the oil price influence by using a non-linear ARDL model.

As can be seen, in all of these studies annual data is used to arrive at a conclusion on the relationship between oil and output. The main reason for that is the lack of GDP data at higher than the annual frequency in all of the MENA countries. The history of these countries has not started until the 1960s, and the biggest sample size on GDP data that is obtainable does not go beyond 50 observations. In a sequence, 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. Therefore, the results obtained in these studies are prone to suffer from biases that are due to the small sample size. The parameter estimates of the impact and their standard errors may be inaccurate and it suffers from parameter estimation errors despite their consistency.

Moreover, with the exception of Nusair (2016), these studies have inferred from a linear relationship. However, as we mentioned previously, the relationship between oil shocks and output is likely to be asymmetric due to reallocation, uncertainty and monetary policy effects. Therefore, measuring a non-linear relation with a linear model will definitely lead to a biased inference on the extent of response of output to oil shocks.

In this paper, we overcome these problems of data limitations in the MENA region by using the industrial output as a proxy for 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 time period and hence, it is closely related to real output particularly in the long term.[13] In our analysis, we focus on the period that followed the global financial crisis and our samples extend from 2006 to 2018 depending on the country. The number of data points ranges from 89 for Egypt to 125 for Tunisia and hence, our sample is relatively large compared to previously investigated samples.

To account for any potential non-linearity between output and oil, we use as Nusair (2016), the non-linear ARDL model of Shin et al. (2014). But unlike Nusair, 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.

The results that we obtain are different but they are intuitive: we find that a rise in the oil price triggers an expansion and a fall triggers a recession. The exception is Tunis in which the relation is the other way around as it is a net oil importer country. These results contrast the

[12] The GCC is an economic block of oil producing countries that include: Saudi Arabia, Kuwait, United Arab Emirates, Oman and Bahrain. All these are countries that belong to the MENA region. The only countries that are found to be affected by a drop in the oil price are Kuwait and Qatar.

[13] The electricity consumption may be also used to proxy GDP. However, it is less correlated than industrial output with economic cycles and its data is only available at the annual frequency.

bulk of the literature on the limited influence of oil price increases (Mehrara, 2008; Moshiri and Banijashem, 2012; Cologni and Manera, 2013) on the economies of the MENA countries. However, our findings agree partially with Nusair's (2016) results with the exception that the negative influence of oil falls is found to be unanimous across all oil net exporters in our sample, a result which is not substantiated by Nusair (2016).

There is significant asymmetry in the response of output to oil price changes in both the long as well as in the short term. The industrial output is found to respond quicker and by more to increases in the oil price than to decreases. The positive long- term impact of an increase in the price of oil is found to be larger than the negative impact of a fall in the oil price. This is found despite the slower adjustment of output in the rise than in the fall of energy prices.

The rest of the paper is organized as follows: In section 2, we outline the methodology that we use to measure the relationship and to test for asymmetry. In particular, we present the specification that will be estimated and the tests for short-term influence, long-term cointegration, and asymmetry. The data set and its characteristics will be provided in section 3. In Section 4, we present the empirical findings. Section 5 checks the robustness of results under a different data generating process. Finally, in section 6 we provide some policy recommendations.

2. Methodology

Suppose that IP_t and OP_t are the real industrial production and the real oil prices in a particular MENA country.[14] A simple asymmetric long run relationship between oil and output can be written as

$$IP_t = \beta^+ OP_t^+ + \beta^- OP_t^- + u_t \tag{1}$$

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

where IP_t and OP_t are assumed to have one cointegrating relationship. Instead of having the long run relationship with 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

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

The formulation in Eq.1 demonstrates a cointegrating relationship between the oil price and the output that could be asymmetric with respect to long-term partial sums of the oil price. If the $|\beta^+| \neq |\beta^-|$, then similar increases and decreases in the oil price will not have the same impact on output. In that sense, the model contains a regime switching cointegrating relationship which is governed by the sign of changes in the oil price.[15]

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

[15] Note that this relationship is not unique as for every trajectory of partial sums in the oil price there is different long-term relationship. The simple model in Eq. 1 has been first applied by Schorderet (2001) to capture the non-linear relationship between output and unemployment.

The expansion of output in MENA countries is not expected to drive the oil price and hence, we do not expect endogeneity problems in the context of this model. However, the model as it stands does not account for the short-term dynamics of the influence of the oil price on economic growth and hence, it is not appropriate for us.[16] A good representation that satisfies our needs is the nonlinear dynamic autoregressive distributed lag model (ARDL) of Shin et al. (2014) as it captures not only asymmetry but also the long and the short-term dynamics.[17]

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

$$IP_t = \sum_{j=1}^{p} \emptyset_j IP_{t-j} + \sum_{j=0}^{q} \left(\theta_j^{+\prime} OP_{t-j}^{+} + \theta_j^{-\prime} OP_{t-j}^{-}\right) + \varepsilon_t \tag{3}$$

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 oil prices OP_t^+ and OP_t^- on the industrial output. In Eq. 3, ε_t is an iid process with zero mean and constant volatility, σ_ε^2.

The relationship in 2.3 can be re-written as:[18]

$$\Delta IP_t = \rho IP_{t-1} + \theta^{+\prime} OP_{t-1}^{+} + \theta^{-\prime} OP_{t-1}^{-} + \sum_{j=1}^{p-1} \gamma_j \, \Delta IP_{t-1} + \sum_{j=0}^{q-1} \left(\varphi_j^{+\prime} \Delta OP_{t-j}^{+} + \varphi_j^{-\prime} \Delta OP_{t-j}^{-}\right) + \epsilon_t \tag{4}$$

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

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

$$\Delta IP_t = \rho ECT_{t-1} + \sum_{j=1}^{p-1} \gamma_j \, \Delta IP_{t-1} + \sum_{j=0}^{q-1} \left(\varphi_j^{+\prime} \Delta OP_{t-j}^{+} + \varphi_j^{-\prime} \Delta OP_{t-j}^{-}\right) + \epsilon_t \tag{5}$$

[16]Furthermore, the serial correlations of the errors may complicate testing as the asymptotic distribution of the parameters may not be Gaussian under these conditions. The OLS estimator may remain consistent, but still the parameters are poorly determined particularly in small samples.
[17] The model extends the autoregressive distributed lag (ARDL) approach of Pesaran and Shin (1998) and Pesaran et al. (2001) in order to capture asymmetry and non-linearity in the relationship between the variables.
[18] It is straightforward to get Eq. 4 from Eq. 3 following Pesaran et al. (2001).

where $ECT_t = IP_t - \beta^{+\prime} OP_t^{+} - \beta^{-\prime} OP_t^{-}$, and it represents the cointegrating vector that describes the error correction term. The parameters $\beta^{+} = \frac{-\theta^{+}}{\rho}$ and $\beta^{-} = \frac{-\theta^{-}}{\rho}$ are the corresponding long-term parameters. Note that unlike the usual cointegrating relationship, this vector is non-linear and it captures the long-term asymmetries of the influence of the oil partial sums on the industrial production.

In Eq.5, we do not expect endogeneity as the oil price is driven by global factors and not by the growth of MENA economies.[19] Also note that by including an appropriate lag structure in Eq. 5, we may free the model from potential serial correlations in the residuals.

However, if the residuals are not independent of the regressors in Eq.5 we may use instruments of the actual changes in the oil price instead. The data generating process of oil price changes can be written in a reduced form as:

$$\Delta OP_t = \sum_{j=1}^{q-1} \psi_j \, \Delta OP_{t-j} + \xi_t$$

where $\xi_t \sim iid\left(0, \sum_{\xi}\right)$, with $\sum_{\xi}$ is a $k \boxtimes k$ positive definite covariance matrix.[20] Thus, the residuals ϵ_t in Eq.5 may expressed conditionally on oil price changes as:

$$\epsilon_t = \omega' \xi_t + e_t = \omega' \left(\Delta OP_t - \sum_{j=1}^{q-1} \psi_j \, \Delta OP_{t-j} \right) + e_t$$

By substituting ϵ_t into Eq.5 and re-arranging we get the following error correction model:

$$\Delta IP_t = \rho ECT_{t-1} + \sum_{j=1}^{p-1} \gamma_j \, \Delta IP_{t-1} + \sum_{j=0}^{q-1} \left(\pi_j^{+\prime} \Delta OP_{t-j}^{+} + \pi_j^{-\prime} \Delta OP_{t-j}^{-} \right) + e_t \qquad (6)$$

where $\pi_0^{+\prime} = \varphi_0^{+\prime} + \omega', \pi_0^{-\prime} = \varphi_0^{-\prime} + \omega', \pi_j^{+\prime} = \varphi_j^{+\prime} + \omega' \psi_j, \pi_j^{-\prime} = \varphi_0^{-\prime} - \omega' \psi_j$ for $j = 1, \ldots. q-1$.

Note that when ρ in Eq.6 is zero, there is no cointegration between oil and output and hence, all the parameters of the non-linear cointegrating vector are zeros. 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. Under the null of no long-term influence, the limiting distribution of the F_{PSS} statistics is found to be non-standard and hence, critical values can be obtained by stochastic simulation or bootstrapping. However, Pesaran et al. (2001) have provided critical bounds that may be used for testing by researchers. Given these bounds, if the computed value of the F_{PSS} test statistics

[19] This can be easily corrected for by using instrumental variables of the changes in the oil price. For instance, we may regress $\Delta OP_t = \sum_{j=1}^{q-1} \pi_j \Delta OP_{t-j} + \vartheta_t$ and use the fitted values in order to get orthogonal partial sums in Eq.5.
[20] k is the number of regressors entering the long-term equation.

exceeds the upper bound critical value, the null hypothesis of no cointegration is rejected. However, if it falls below the lower bound, then oil and output are not cointegrated. A value of the computed test statistics that lies between the provided bounds, indicate inconclusive results.

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 2, 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.[21]

The specification in Eq. 6 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. Data Set

To investigate non -linear cointegration, long and short-term asymmetry of the oil-output relationship in the MENA economies, we use monthly data on the WTI crude oil prices as well as on the industrial production of five countries. These countries are Egypt, Tunis, the United Arab Emirates, Saudi Arabia, and Kuwait.[22]

For each country, the sample covers a different period depending on the availability of the data. In particular, 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 on 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; The Kuwaiti data from July 2009 to October 2016 for a total of 88 observations; and finally, the Tunisian data from October 2007 to March 2018 for a total of 125 observations.

As nominal prices of oil in domestic currency may be associated with output through inflation, we focus our attention on how the real prices of oil are linked to the real industrial output. Both domestic output and oil prices increase with inflation and this may create a spurious relationship between the two variables. This is not to say, that a hike in the oil price can be inflationary in some of the countries and this may discourage investments and macroeconomic growth.[23] However, if this is likely, then it will be captured through the relationship between the real price of oil and the real industrial production.

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

[22] Our analysis restricted only to these MENA countries due to data availability. Specifically, data on industrial output and other macroeconomic variables for other MENA countries are not available on a monthly basis.

[23] As mentioned previously, oil is a strategic commodity and the rise in its value may influence core inflation, monetary policy and subsequently economic growth.

Therefore, 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. All data are retrieved from Thomson Reuters DataStream.[24]

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. For instance, the big rally in the oil prices prior to the global financial crisis is associated with large increases in the industrial production of Saudi Arabia, Tunisia and the United Arab Emirates.[25] Similarly, the industrial output of Saudi Arabia, Tunisia and the UAE has dropped significantly with the fall of oil prices during the global financial crisis in 2008. The recent fall in oil prices between 2014 and 2016 has been associated with corresponding falls in the industrial production of MENA countries as can be seen in the figures. This is not unexpected for the oil exporter countries of the MENA region, as higher oil prices in these countries may increase resources available for spending and thus economic growth.

It is worth here to mention that the transmission from oil to output may cross through various channels. For instance, the increase in the oil price will increase the export revenues and consequently government spending and the growth of the oil exporter countries of the MENA region such as the UAE and Saudi Arabia. However, for the oil importer countries, the hike in energy cost will burden the government budget as energy prices are subsidized in most of these economies.[26] Therefore, the short-term effect on domestic output might not be as strong, but the longer-term implications are more taxes, less government spending and lower growth of industrial production.

But the graphs in Figure 1 are not supportive of these ideas. In fact, the influence of oil is uniformly positive across oil importers and exporters of the region. It is well known that the economies of the MENA region are dependent on oil and that the rise in oil benefits the economic development of the whole region through cross country foreign direct investment, trade and employment. The capital inflows into the petrodollar economies find its way as investments in other neighboring Middle Eastern economies. Moreover, with the expansion of oil exporter economies, labor migrate from oil importer Middle Eastern economies into these economies. Part of the income generated by the labor movement is transferred to home countries, and these transfers tend to support domestic spending, development and economic growth.

Table 1 presents summary statistics of the log real oil price and industrial production 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

[24] From DataStream we find only monthly oil prices and monthly industrial production denominated in dollars. To obtain values in domestic currency we multiplied by the exchange rate. The oil price and the industrial output are then obtained at the June, 2018 constant prices.

[25] Right before the global financial meltdown in 2008, the price of crude oil has reached $ 145 per barrel.

[26] In Saudi Arabia, the UAE and Kuwait, energy is sold below its international market value. In Egypt, the country went under a structural adjustment program and energy subsidies are subsequently removed.

normality of the oil price at conventional levels. This negative skewness is unexpected as most commodities including oil are exposed to supply shocks and thus, they are more prone to be positively skewed. However, during the period of our sample, oil suffers sharp declines during three times: in 2008, in 2014 and in 2016.[27] It is possible that these sharp declines in the oil price have caused the time series of oil to be negatively skewed.

Industrial production does not have a consistent pattern across countries. It is positively skewed in Egypt, Tunisia, and Saudi Arabia, but negatively skewed in the UAE and Kuwait. There is some excess kurtosis in the industrial production time series, but the null of normally distributed industrial output is not rejected in Egypt, Saudi Arabia, and Kuwait. Note also that the volatility of oil is almost three folds the volatility of industrial output. The lower volatility and the normality of the industrial output indicate that its time series is more well behaved and that it is easier to model and analyze than the price of oil.

Before making any inference using regressions, we first check the stationarity of our variables. Table 2 displays the Augmented Dicky Fuller Test of unit roots in the levels, the first differences and the second differences of the real oil price and the real industrial output time series. In the specification used to infer stationarity, we include a constant, a time trend and we account for potential dynamics and autocorrelation in the real oil and output for up to 11 lag months. As can be seen in the table, the null hypothesis of a unit root in the level of the real oil price is not rejected for all countries. However, the first differences of the oil price seem to be covariance stationery as the null of a unit root is strongly rejected at the 1% level. The table also shows that the industrial output levels contain unit roots with the exception of the Tunisian industrial output. Surprisingly, the first differences of the Kuwaiti and Saudi industrial output are covariance non-stationary, but the second differences are found to be stationary.

In the non-linear model we are using we regress on negative and positive changes in the oil price. Therefore, we performed the ADF unit root test over oil price asymmetric innovations in all countries and we find that positive and negative oil price components are nonstationary at the levels and stationary at their first differences. Thus, we may conclude that the oil prices along with their positive and negative components are predominantly integrated and thereby the non-linear model is suitable for our empirical analysis.[28]

It is well known that the standard ADF unit root test does not take into account any structural breaks or nonlinearities in the investigated time series (See, Perron, 1989; Nazlioglu, 2011). A robust test is the Lee et al. (2012) unit root test. It is an LM Lagrange Multiplier test that allows for the endogenous determination of the time and the size of the break at both the level and the trend of the data generating process.[29]

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[27] The nominal price of oil has dropped from around $133 per barrel in July 2008 to $39 in February 2009. It has also dropped from $103 in July 2014 to $59 in December 2014 and subsequently to $30 by the end of February 2016. The first drop is caused by the uncertainty created by the global financial meltdown in 2008. The drop in 2014 is caused by the refusal of Saudi Arabia to reduce output in order to support the oil price during the OPEC conference meetings. The cooperation in the OPEC has started to collapse.

[28] To economize on space, results are not reported, but available from authors upon request.

[29] There are other tests that allow for the determination of time and size of breaks endogenously. For instance, there are the tests by Zivot and Andrews (1992), Perron (1997), and Lumsdaine and Papell (1997). However, all these tests suffer from size inaccuracies and tend to reject the null more than expected. On the contrary, the Lee

Consider the following data generating process:

$$y_t = \delta' Z_t + \varepsilon_t,$$
$$\varepsilon_t = \beta\varepsilon_{t-1} + u_t \qquad (7)$$

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. [30] 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:[31]

$$Inf\ \tilde{\tau}(\tilde{\lambda}) = Inf_{\lambda}\tau\lambda, \qquad \text{where } \lambda = T_B/T \qquad (8)$$

The results of the tests for two structural breaks are all reported in Table 3. The t-statistics associated of 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. Because the level of the variables is I(1) process, cointegration analysis is suitable.

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 levels of the variables break at different times across countries. For instance, in 2008, oil prices break in Tunisia and the UAE while it breaks in Saudi Arabia only in 2014. Similarly, the industrial output level breaks in 2010 in Tunisia, Kuwait and Saudi Arabia while it only breaks in 2012 in Egypt and the UAE.

The breaking dates in the difference of the variables also varies across countries. However, the breaks in the change of the industrial output occurs in the period of the political turmoil in Egypt in 2011 and it also occurs around the global financial crisis in Saudi Arabia, UAE and Tunisia.

In the net oil importer countries such as Egypt and Tunis the breaks of the industrial output lag the breaks in the oil price. For example, the change in the oil price breaks at the beginning of 2008 and 2014; but the structural break in the change of output occurs around the end of these years. Similar pattern is displayed by Saudi Arabia.

Column 6 and Column 7 displays the Lee-Strazicich unit root tests under a data generating process that contains breaks in the levels and the trend. The columns show similar results to the ADF unit root test in that the null of unit root is rejected in the time series difference of

et al. (2012) test is more powerful and it has a more accurate size. See also the tests in Lee and Strazicich (2003, 2004) for more information.

[30] Needless to say if two structural breaks in the level and the trend, the Z_t vector becomes $Z_t = [1, t, D1_t, D2_t, DT1_t, DT2_t]'$, where $D1_t$, and $D2_t$ are dummy variables that capture the two breaks.

[31] The critical values of the LM unit root test statistic are tabulated in Lee and Strazicich (2003, 2012).

both the oil price and the industrial output. This result is found to be uniform across countries at the 5% significance level.

To further check the suitability of the non-linear specification, we use the BDS test of Brock et al. (1996) to detect nonlinearity and serial dependence in our data. The test results indicate nonlinearity in all series and it provides further justification for the non-linear specification.[32]

4. Empirical Findings

At the start of our analysis, we assess nonlinear causality between oil price changes and output changes in the five MENA countries using a non-linear granger causality test as in Bekiros and Diks (2008). The test results are presented in Table 4. As expected, negative and positive changes in the prices of oil significantly influence the industrial production. The result is significant at the 5% level and it is uniform across all countries in the sample.

To appreciate non-linearity and asymmetry we run two regressions: a static regression model and a non- linear asymmetric regression model. The results are presented in Table 5.

In the static regression, we regress the real industrial production on the oil price, a trend and a constant. The assumption is one long-term equilibrium relationship that is linear and symmetric. Panel A of Table 5, displays the parameter estimates and the diagnostics of the error.[33] The table shows that the real oil price has a negative and significant influence on the Tunisian industrial production, whereas it positively influences the output of the rest of countries. The fit of the model is not bad as the adjusted coefficient of determination is more than 50% for all countries. However, the diagnostics of the errors are problematic and they indicate that the model does not capture the dynamics of the variables and hence, it is not suitable for inference. The Breusch Godfrey test rejects the null of no serial correlations of the residuals and the Breusch-Pagan-Godfrey test rejects the null of homoscedastic errors. Similarly, the Ramsey RESET test rejects the suitability of the functional form.

To enhance the specification, we model the long-term relationship of output as a function of positive and negative partial sums. Although the negative and positive sums are linearly related to output in the formulation, this linearity is only piecewise and the model is genuinely non-linear. Thus, the model allows for asymmetry in the influence of the real price of oil on output. Finally, note that this model is not assuming a unique linear relationship that is returned to after the perturbation of the system. On the contrary, the relationship is dependent on the decomposition of the partial sums of the oil price.[34]

The estimates of this static asymmetric specification are displayed in Panel B of Table 5. As can be seen in the panel, the fit of the model has improved. The coefficient of determination has jumped up in all countries with the exception of the UAE.

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[32] To save on space, these results are not reported but available from the authors upon request.
[33] To improve the fit, we included a time trend.
[34] Changed negative and positive partial sums implies another cointegrating relationship. In that sense, the cointegrating vector is not unique as in linear relationships.

The model's parameters show that the cumulative increases in oil prices benefit output in all countries with the exception of the Tunisian industrial production which expands (contracts) after decreases (increases) in the oil price. Tunis is a net importer of oil and this explains the negative effect of a hike in the price of energy on its small economy. However, the influence of oil on Egypt's industrial output which is another net importer in the sample is at stark difference. Egypt's industrial output surprisingly expands after an increase in oil prices and contracts after a decrease. But Egypt is different than Tunisia in that it has become a net importer of oil only after 2010, whereas Tunisia has been always a net importer over the sample period.[35] The result here is consistent with the literature on the impact of oil shocks. 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.[36]

The Wald statistics which tests for the equality of the coefficients associated with OP_t^+ and OP_t^- rejects the null of equal parameters. Hence, the model implies asymmetry in the influence of oil shocks on the industrial production. In particular, output expands after cumulative increases in the real price of oil more than it contracts after cumulative decreases. For instance, a 1% cumulative increase in the real price of oil will increase real industrial production by 0.06%, 0.11%, 0.19% and 0.45% in Saudi Arabia, Kuwait, UAE and Egypt respectively. On the other hand, a 1% decrease in the oil price will lead to a contraction of only 0.014%, 0.07%, 0.106% and 0.263% in Saudi Arabia, Kuwait, UAE and Egypt respectively.[37] Surprisingly, Egypt's industrial output is the most sensitive to oil price fluctuations among the sample countries.

Still, this model is not suitable for inference as it does not allow for short-term dynamics and the diagnostics of the residuals implies that the model is misspecified. In particular, the errors from the model are serially correlated as shown by the Breusch Godfrey test. Hence, the dynamics of the data is not fully accounted for. Furthermore, heteroskedastic residuals are not rejected and the reset test shows that the specification is not suitable for the variables.

Therefore, we proceed to estimate a nonlinear cointegrating autoregressive distributed lag model (ARDL) as in Eq. 6. In addition to the long-term relationship and asymmetry, note that this specification also accounts for the short-term dynamics of the industrial output, and the dynamics of positive and negative changes in the cumulative sums of the oil price. The specification also takes care of asymmetry in the influence of positive and negative changes in the partial sums of oil prices over the short term. The richness of the specification allows for more understanding of long- and short-term association and asymmetry in the oil-output association.

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[35] Tunis produces some oil from El Borma and Ashtart fields, but it imports large proportions of its oil needs from Libya. Egypt is different as it produces most of its needs domestically. For instance, in 2017, Egypt has produced 660 thousand and consumed 816 thousand barrels of oil.

[36] 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).

[37] For Tunis, a drop of 1% expands output by 0.1% while an increase of 1% reduces output by 0.05%. Hence, Tunisian output is two folds more sensitive to oil price decreases than to increases.

Table 6 presents the parameter estimates, the non-linear cointegration tests of the oil output relationship and the diagnostics of the residuals. As can be seen in the table, the model fits data very well and it captures its short term as well as its long-term dynamics. The optimal number of the lags of partial sums of oil changes and the industrial output is chosen using AIC information criteria which have been checked up to 11 lags.

The table shows that unlike previous models, the residuals here are serially uncorrelated, homoscedastic and the functional form appears to be suitable conditional on the data set. Therefore, this model is appropriate to make inference on long- and short-term association between real oil prices and the industrial output.

In terms of long-term relationship, the table 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.[38] The short-term changes of industrial production are influenced by the deviation of output from the long-term relationship between industrial production and partial sums of the real oil price. The same result is inferred from the F_{PSS} bounds test of Pesaran, Shin and Smith. The two countries that are found with weak cointegration evidence are Egypt and Kuwait.

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 estimated long -term response of industrial production to a 1% increase in the partial sum of positive changes in the real oil price is 0.46%, -0.04%, 0.366%, 0.399%, 0.322% for Egypt, Tunisia, UAE, Saudi Arabia, and Kuwait respectively. This can be compared with an output response of -0.24%, 0.089%, -0.208%, -0.274% and -0.147% that result from a decrease in the oil price of the same countries respectively. The positive long-term influence of oil price rallies seems to be greater in the longer term than the negative influence of oil price falls.

The short-term parameters of the influence of changes in the oil price are also significant particularly when there is an increase in the oil price. 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.

The long- and short-term asymmetry tests are included in Table 7. The table shows that there is substantial asymmetry in the response of the real industrial output in the MENA region to the oil prices in both the short as well as the long term. This result is significant and uniform across all countries. The only exception is the response of Tunisian industrial output which

[38] As mentioned previously here we test the null of $\rho = 0$ against the alternative of $\rho < 0$ in 2.5. The parameter ρ is the adjustment speed parameter that is associated with the error correction term in the non-linear ARDL model.

seems to be symmetric, but only in the short run. The economic players in the MENA region are quick to increase their spending and investments following oil price increases but hesitate to reduce it following oil declines.

A potential explanation of asymmetry lies in the behavior of Governments in the oil exporter countries of the MENA region. These countries have public budgets that are balanced at a relatively low price 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.[39] 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.[40] 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.[41]

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 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.[42] 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.[43]

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 2 depicts how the cumulative dynamic multipliers of output are changing across time following positive and negative oil shocks.[44]

The Figure contains three lines and a band. The green line shows how the equilibrium is adjusting to an increase in the oil price. The red line depicts the response to a drop in the prices of oil. The blue middle line is the line that shows asymmetry in the adjustment of equilibrium

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[39] Source: Fitch, High Mark Capital, Capital, IWF, WSJ.
[40] 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.
[41] Note that domestic oil prices are controlled and hence, the adjustment effect in minor.
[42] The only potential adjustment is the reallocation of resources into the energy sector as it is now more profitable due to higher oil prices.
[43] 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.
[44] Recall that these multipliers are the summation of infinitesimal responses of the real industrial output to changes in positive and negative cumulative sums of the real oil price across time. The multipliers converge to the long-term response parameters as the time period becomes very long.

to positive and negative changes in oil prices. The line offsets the impact on the equilibrium of similar positive and negative shocks to the cumulative sums of oil prices. 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 around the line is the 90% confidence interval which we have 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.

In Figure 2, 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 2 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 2 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.

Although the same applies to the changes in industrial production as a result of an increase in the oil price, the adjustment is slower as it occurs over longer periods of time. Notice that the green lines in oil exporter countries are concave while the red lines are convex. These lines indicate that while the industrial production drops fast as a result of a negative oil shock it increases slowly in response to positive shocks. In the oil importer countries, adjustments are faster and they occur within one year.

A possible explanation of this slow adjustments is 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 to absorb the shocks very 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.

5. Robustness analysis

To see if inference is able to stand a change in the data generating process, we estimate the bivariate nonlinear VAR model of Kilian and Vigfusson (2011a, b) and then test for asymmetry in the responses of the real industrial output to oil price changes.

Specially, we estimate the following structural model using 12 monthly lags:[45]

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

[45] 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).

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

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. An OLS estimator of the two-equation model above is consistent and efficient. The presence of asymmetry can be inferred by testing the null that the slope coefficients corresponding to OP^+_{t-i} are all equal zero; i.e. $H_0: \gamma_{21,i} = \gamma_{12,i} = 0$ for all i. This slope-based Wald test is asymptotically distributed as χ^2_p. Table 8 displays the slope-based test results using 12 lags. The Wald test rejects the null that the corresponding parameters of the maximum of the oil price changes are equivalent and equals to zero at the 0.01% significance level in all countries. Thus, the asymmetry in the response of output to oil changes is more likely.

To see if the paths of response of 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} above is the impulse responses of output to oil shocks. These impulses are functions of the horizon, h that extends from $0, 1, \dots, H$, and of the size of oil shock which is referred to as δ. Under the null a Wald test statistics has an asymptotic distribution of $\chi^2_p(H + 1)$ and thus, it can be used to assess symmetry in the responses of output at various horizons.

Table 9 reports the p-values of the test of symmetry in the impulse response of industrial production to shocks in oil for horizons that extends forward from two months to one year. The test is conducted for one and two standard error $\hat{\sigma}$ shocks in the oil price. As can be seen in the table, the impulse responses are not symmetric for relatively large shocks in the oil price. This result is significant and uniform across all countries. However, when the shock size is relatively small, the null of symmetry is only rejected for short horizons.[46] 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 3.

6. Conclusion and Policy Implications

In this research, we provide recent evidence on the asymmetric influence of oil price changes on the industrial output of five MENA countries. The paper contributes to the literature in various ways: first, it provides evidence from a relatively larger sample compared to the related literature. The industrial production is used to proxy output in order to get more observations; Second, it uses a non -linear model that accounts for asymmetries and non-linearities in the relationship between oil and output; Third, it estimates a sample that contains three big net oil

[46] The Tunisian industrial output to small shocks in oil seems to be symmetric for all horizons.

exporters and hence, it provides evidence on the nature of asymmetry in net oil exporter countries whereas most of the literature's interest lies on net oil importers.

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.

Theoretically, oil price fluctuation in either direction should create uncertainties and economic reallocation costs that worsen the bad influence of a drop in the oil price and moderate the good influence of oil market rises. However, our results are not supportive of this theory as we find asymmetry in the opposite direction. This has been explained by the increase in confidence and certainty in the MENA region following rises in the price of oil. It can also be explained by the vast amount of resources invested in the sovereign wealth funds and these are used in order to support public spending in periods of extended falls in the oil price.

The findings in this paper are important for politicians and policy makers in the MENA region. First, the oil price plays a crucial role in the long- and short-term economic performance of countries. When prices are high, economies grow and perform. But the danger to this growth and employment lies when the oil price falls. As governments in the region monopolize the production and the distribution of oil, 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.[47] Similarly, there should be some regulations on oil sensitive businesses that incentivize them to explicitly discuss and 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. The current situation is budgets that depend on oil revenues and an extremely light tax regime. The diversified sources of revenues reduce the influence of oil price falls as well as rises on public spending. 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 staffed with more resources. However, these funds should be mandated to support the economy against oil price volatility. This is important as the mandate will influence the management of assets such that these funds will assume exposures to perform better when oil prices are low. This can be done by an allocation which is weakly correlated with energy markets.

[47] These can be bought in the international markets as put options or OTC bespoke insurance contracts.

The government in oil exporter countries should be aware of the asymmetries in the response of domestic output to oil price shocks. For instance, when prices increase and confidence rise, governments should expect domestic spending and output to increase at the current level of public spending. Therefore, if the government increases its spending, the economy may overheat and prices may start to increase. Therefore, governments should decide on their additional budget after seeing how the economy is growing. The additional funds could be invested in the sovereign wealth funds in order to support spending during periods of oil price falls.

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. In these countries, a national strategy that aims to increase dependence on clean energy sources is crucial for the future development of these countries. Accounting for energy risk in government and corporate strategies is also important. These countries are also encouraged to contract their energy needs long term when the oil prices are low.

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Table 1: Descriptive statistics of level variables

	Real industrial production (IP)					Real oil prices (OP)				
Country	Mean	Std. dev.	Skewness	Kurtosis	Jarque-Bera	Mean	Std. dev.	Skewness	Kurtosis	Jarque-Bera
Egypt	10.993	0.084	1.304	3.365	26.015***	3.012	0.153	-1.088	2.999	18.171***
Tunisia	9.343	0.036	0.111	2.800	0.470	2.197	0.121	-0.666	2.643	10.231***
UAE	10.809	0.0432	-0.3017	2.198	4.442	2.470	0.165	-0.384	1.915	9.292***
Saudi Arabia	11.102	0.038	0.632	2.814	8.093**	2.488	0.166	-0.456	2.320	7.495**
Kuwait	9.399	0.039	-0.502	2.214	5.957*	1.357	0.151	-0.624	1.982	11.673***

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 = 11)

	Real industrial production (IP)						Real oil prices (OP)			
Country	Level		First Difference		Second Difference		Level		First Difference	
Egypt	-2.763	(0.214)	-8.538**	(0.000)			-1.989	(0.598)	-6.851***	(0.000)
Tunisia	-4.908***	(0.000)	-4.491***	(0.002)			-2.583	(0.288)	-8.370***	(0.000)
UAE	-2.885	(0.171)	-	-			-2.549	(0.304)	-7.424***	(0.000)
Saudi Arabia	-2.505	(0.325)	-2.7869	(0.205)	-8.198***	(0.000)	-3.098	(0.110)	-8.000***	(0.000)
Kuwait	-1.695	(0.744)	-2.291	(0.433)	-4.835***	(0.001)	-2.134	(0.520)	-7.875***	(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	0.082	-0.200	-0.145*
					(-2.275)	(0.877)	(5.660)	(-1.729)
OP	-5.749	8	2010:10	2012:10	-0.097***	0.138***	0.036	-0.060*
					(-5.345)	(5.988)	(0.886)	(-1.339)
First Difference								
ΔIP	-12.929***	7	2012:10	2013:5	-0.271***	0.295***	0.564***	-0.141***
					(-4.944)	(4.011)	(7.366)	(-3.763)
ΔOP	-7.144***	2	2011:2	2013:4	0.058***	0.011	-0.128**	-0.097**
					(4.522)	(0.819)	(-2.786)	(-2.164)
Tunisia								
Level								
IP	-4.409	6	2010:1	2015:12	-0.029	0.032	0.063**	-0.034*
					(-1.812)	(1.295)	(2.957)	(-1.703)
OP	-5.317*	2	2008:6	2014:1	0.019**	-0.055***	-0.010	-0.050
					(2.071)	(-4.380)	(-0.298)	(-1.427)
First Difference								
ΔIP	-9.212***	11	2008:11	2014:9	0.091***	-0.100***	-0.120***	0.109***
					(9.017)	(-9.586)	(-5.541)	(5.236)
ΔOP	-7.545***	2	2008:1	2014:3	-0.072***	0.049***	0.250***	-0.090**
					(-4.697)	(5.432)	(7.301)	(-2.437)
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)
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)
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)
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)
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
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)

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 non-linear Granger causality test (Asymmetric)

	Real oil prices ≠> Real industrial production		Real industrial production ≠> Real oil prices	
Country	Test Statistic	p-value	Test Statistic	p-value
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

Note: The symbol "≠>" implies no Granger-causality. The optimal Embedding dimension = 2. The series are in first differences. The test statistics is the Bekiros and Diks (2006, 2008) nonparametric Granger causality test statistics that is based on the correlation integral between the time series. It rests on the Hiemstra and Jones (1994) test but it relaxes the assumption that the time series is an iid process. The Panchenko's C++ code is used to get the test statistics and the p-values.

∗∗∗ $p < 0.01$.

∗∗ $p < 0.05$.

∗ $p < 0.1$.

Table 5: Static Estimation of the pass-through of oil prices (OP) to Industrial Production (IP)

	Egypt		Tunisia		UAE		Saudi Arabia		Kuwait	
Panel A: Static Linear Regression										
OP_t	0.351***	(0.000)	-0.090***	(0.000)	0.140***	(0.000)	0.053**	(0.013)	-0.146***	(0.000)
Trend	0.003***	(0.000)	0.001***	(0.000)	0.001***	(0.000)	0.005***	(0.000)	0.001***	(0.000)
Constant	9.678***	(0.000)	9.501***	(0.000)	10.379***	(0.000)	10.967***	(0.000)	9.309***	(0.000)
R^2	0.572		0.511		0.591		0.623		0.637	
R^2_{adj}	0.562		0.503		0.583		0.610		0.628	
χ^2_{SC}	56.310***	(0.000)	45.90***	(0.000)	27.618***	(0.000)	70.67***	(0.000)	30.19***	(0.000)
χ^2_{H}	4.94**	(0.026)	0.66	(0.417)	6.03**	(0.014)	12.59***	(0.000)	4.82**	(0.028)
χ^2_{FF}	65.37***	(0.000)	3.69**	(0.013)	3.09**	(0.030)	35.13***	(0.000)	14.52***	(0.000)
Panel B: Static Asymmetric Regression										
OP_t^+	0.453***	(0.000)	-0.058**	(0.022)	0.191***	(0.000)	0.067***	(0.000)	0.114***	(0.001)
OP_t^-	-0.263***	(0.000)	0.100**	(0.020)	-0.106***	(0.000)	-0.014***	(0.001)	-0.007**	(0.046)
Constant	10.907***	(0.000)	9.30***	(0.005)	10.758***	(0.000)	11.147***	(0.000)	9.343***	(0.000)
R^2	0.717		0.520		0.465		0.711		0.644	
R^2_{adj}	0.711		0.510		0.454		0.699		0.635	
χ^2_{SC}	44.94***	(0.000)	44.88***	(0.000)	41.95***	(0.000)	65.09***		30.11***	(0.000)
χ^2_{H}	1.51	(0.219)	1.19	(0.275)	7.75***	(0.005)	5.38**	(0.020)	3.55*	(0.059)
χ^2_{FF}	67.97***	(0.000)	3.62**	(0.015)	9.54***	(0.000)	30.77***	(0.000)	8.94***	(0.000)
$W_{OP^+=OP^-}$	210.12***	(0.000)	66.90***	(0.000)	87.62***	(0.000)	93.83***	(0.000)	80.88***	(0.000)

Notes: OP_t denotes the natural logarithm of oil price. The superscripts "+" and "–" denote positive and negative partial sums, respectively. In order to accommodate the strong trending behavior of OP_t, we include a deterministic time trend in the symmetric regressions. χ^2_{SC}, χ^2_{H}, and χ^2_{FF} are the Breusch Godfrey test for higher-order serial correlation. Breusch-Pagan-Godfrey Heteroskedasticity., and Ramsey RESET test for functional form, respectively. $W_{OP^+=OP^-}$ is the Wald test of the equality of the coefficients associated with OP_t^+ and OP_t^-. Numbers in brackets are the associated p-values.

*** $p < 0.01$.

** $p < 0.05$.

* $p < 0.1$.

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

	Egypt		Tunisia		UAE		Saudi Arabia		Kuwait	
IP_{t-1}	-0.265***	(0.003)	-0.373***	(0.000)	-0.420***	(0.000)	-0.124**	(0.025)	-0.173**	(0.034)
OP^{+}_{t-1}	0.122**	(0.020)	-0.015**	(0.045)	0.154***	(0.000)	0.050***	(0.006)	0.056***	(0.008)
OP^{-}_{t-1}	-0.065*	(0.063)	0.033*	(0.072)	-0.088***	(0.000)	-0.034**	(0.012)	-0.075**	(0.030)
ΔIP_{t-1}	-0.153	(0.106)	-0.080	(0.422)	-0.279***	(0.001)	-0.372***	(0.000)	-0.376***	(0.000)
ΔIP_{t-3}									-0.425***	(0.000)
ΔIP_{t-7}					-0.298***	(0.000)				
ΔIP_{t-9}	0.014	(0.866)								
ΔIP_{t-10}							-0.362***	(0.000)		
ΔIP_{t-11}			-0.189**	(0.042)						
ΔOP^{+}_{t}	0.790***	(0.000)	0.045	(0.719)	0.442***	(0.000)	0.314***	(0.001)	0.186**	(0.011)
ΔOP^{+}_{t-2}	0.129	(0.217)	-0.008	(0.936)			0.132**	(0.030)	0.048	(0.626)
ΔOP^{+}_{t-3}					0.011	(0.906)				
ΔOP^{-}_{t}	-0.006	(0.967)	-0.036	(0.663)	-0.137**	(0.043)	-0.024**	(0.042)	-0.134***	(0.006)
ΔOP^{-}_{t-2}	0.130	(0.382)			-0.099*	(0.072)	-0.034***	(0.001)		
ΔOP^{-}_{t-4}			0.027**	(0.042)					-0.085***	(0.004)
Constant	2.879***	(0.003)	3.469***	(0.000)	4.494***	(0.000)	1.355**	(0.028)	1.612**	(0.035)
$L_{OP^{+}}$	0.460***	(0.000)	-0.040**	(0.043)	0.366***	(0.000)	0.399***	(0.000)	0.323***	(0.007)

L_{OP^-}	-0.245**	(0.012)	0.089	(0.128)	-0.208***	(0.000)	-0.274***	(0.000)	-0.147	(0.246)
R^2	0.390		0.169		0.440		0.645		0.517	
R^2_{adj}	0.329		0.114		0.394		0.613		0.468	
χ^2_{SC}	6.53	(0.899)	7.58**	(0.321)	8.98	(0.516)	0.691	(0.503)	0.407	(0.476)
χ^2_{H}	1.560	(0.110)	1.47	(0.225)	2.088	(0.352)	2.265	(0.282)	1.269	(0.252)
χ^2_{FF}	3.410	(0.314)	3.190	(0.210)	2.391	(0.531)	2.556	(0.120)	3.906*	(0.070)
t_{BDM}	-3.037		-4.135		-4.783		-4.273		-2.159	
F_{PSS}	3.120		5.826		11.260		8.120		2.164	

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, Dolado and Mestre (1998) t-statistic while F_{PSS} denotes the Pesaran, Shin and Smith (2001) F-statistic for bounds test respectively. 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 9: Testing the symmetry of the response, $H_0 : IRF_{IP}(h, \delta) = -IRF_{IP}(h, -\delta)$ for $h =, 0, 1, \dots, H$

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

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=σˆ and two standard deviation shocks, δ=2σˆ). p−values are based on the χ^2_{H+1}. The estimated impulse response functions computed using 10,000 bootstrap simulations.

∗∗∗ $p < 0.01$.

∗∗ $p < 0.05$.

∗ $p < 0.1$.

Figure 1: Standardized real prices of oil and industrial production

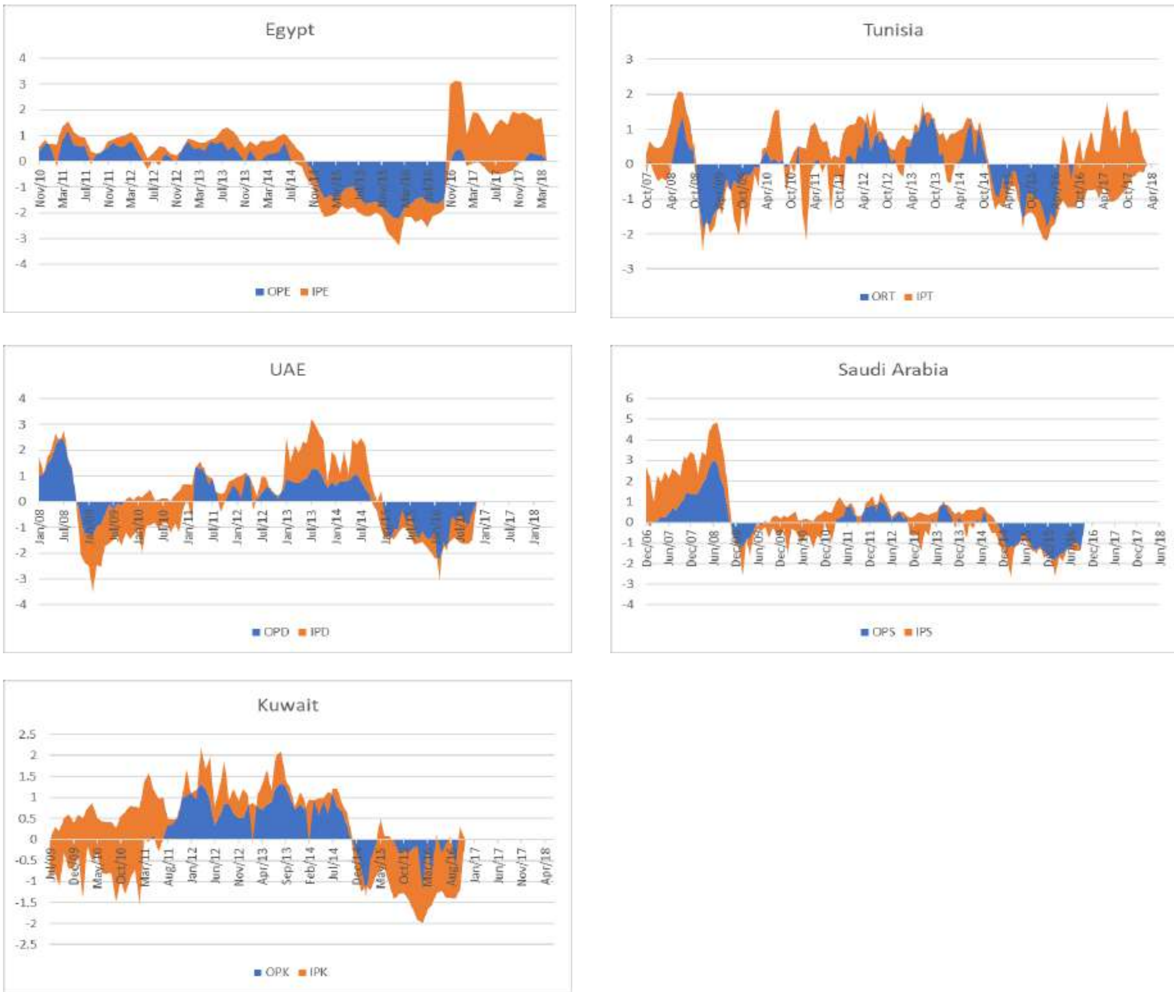
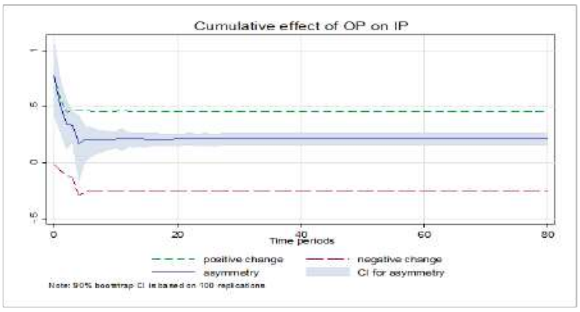
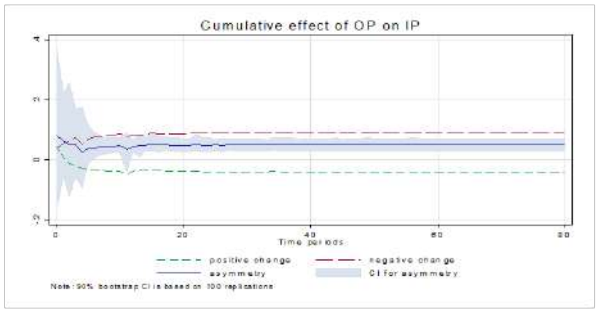


Figure 2: The oil-industrial production tradeoff dynamic multipliers

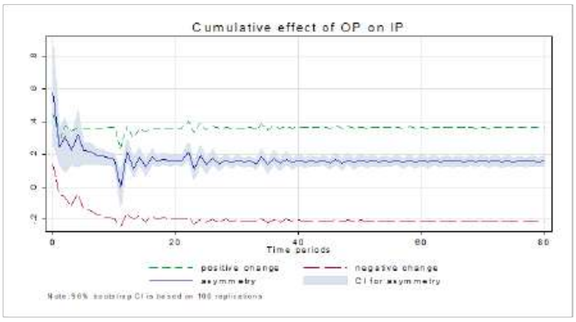
Egypt



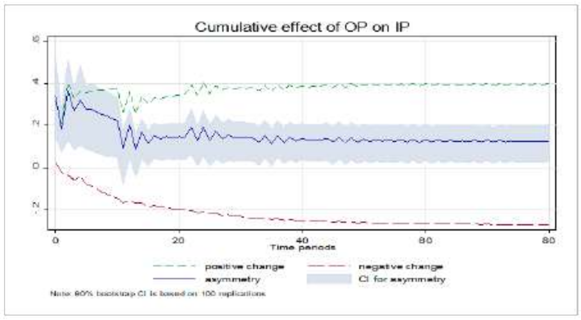
Tunisia



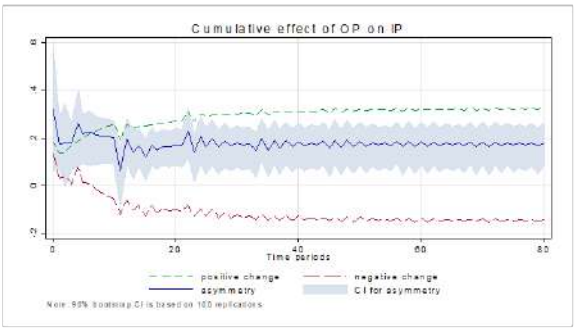
UAE



Saudi Arabia



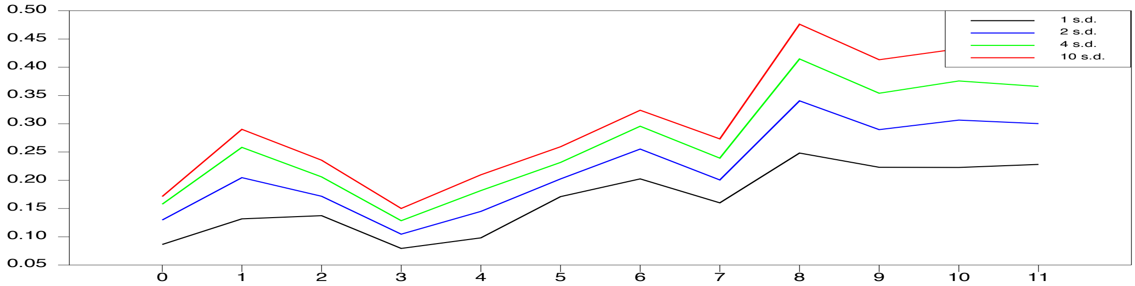
Kuwait



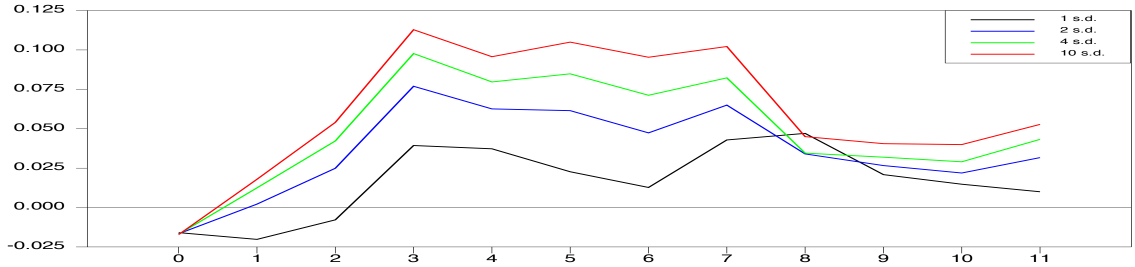
Notes: These graphs give cumulative effects of positive and negative oil shocks on industrial production. Shade areas are the 90% confidence intervals. The imposed restrictions are in line with the identified asymmetries in Table 4.

Figure 3: The response of industrial production to a positive oil price shock by shock size

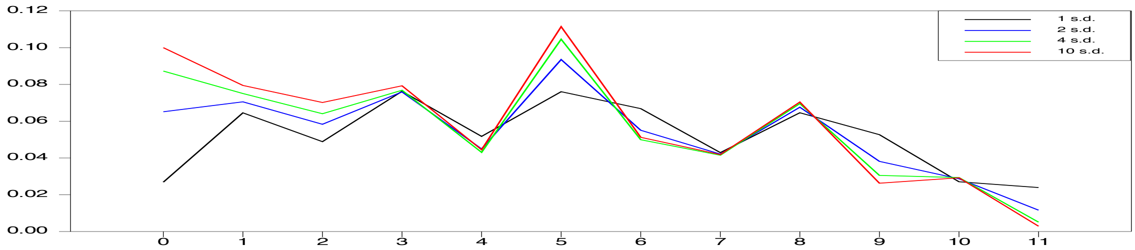
Egypt



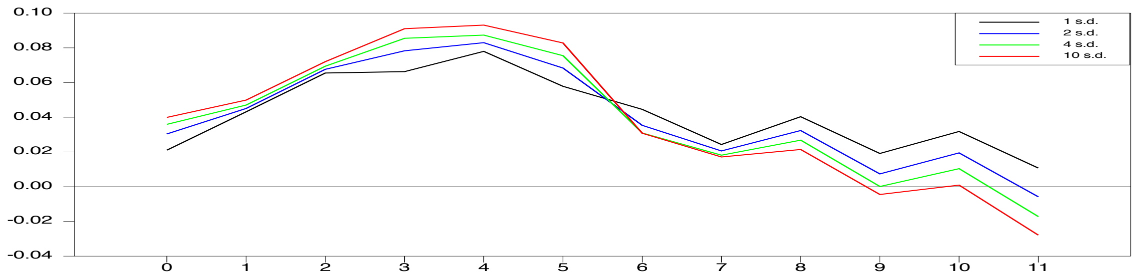
Tunisia



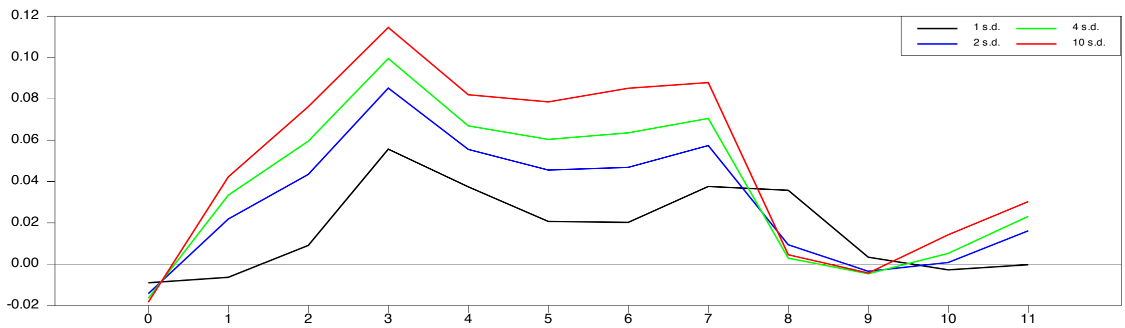
UAE



Saudi Arabia



Kuwait



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