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Benchmark Prices and Iraqi Oil Prices: The Asymmetric Effects of Benchmark Prices on Three Iraqi Oil Blends

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ABSTRACT

This paper examines the asymmetric effects of benchmark oil prices on the prices of the three major Iraqi oil blends (Basrah Light, Basrah Heavy and Kirkuk) using Kilian and Vigfusson's (2011) non-linear VAR specification. The empirical evidence reveals that a decrease in benchmark prices decreases Basrah Light and Kirkuk oil blends more than an increase in the benchmark increases the prices of these two Iraqi blends for the October 2002–October 2019 period. However, the asymmetric behavior of Basrah Heavy is the reverse for the April 2015-October 2019 period. Moreover, as the magnitude of the benchmark oil price shocks increases, the degree of asymmetry increases. This shows that Iraq cannot benefit from oil price increases and market developments for its two most important export blends: Basrah Light and Kirkuk.

Keywords: Crude Oil Prices, Benchmark Prices, Asymmetric Effects
JEL Classifications: O13, Q41

1. INTRODUCTION

Oil is one of the most important commodities affecting every country's macroeconomic performance. Approximately 80% of the proven oil reserves in the world belong to members of the Organization of the Petroleum Exporting Countries (OPEC) (Oil and Gas Journal, 2021). Iraq has the fifth largest oil reserves in the world and is the second largest OPEC producer (Oil and Gas Journal, 2021). Moreover, the Iraqi economy, specifically the government budget, depends heavily on its oil revenues. Thus, understanding the dynamics of Iraqi oil prices is important for the world oil markets and the Iraqi economy. However, oil has inelastic demand and supply curves (Caldara et al., 2018); thus, a slight change in quantity demanded or supplied can generate considerable price changes and affect the level of oil revenue generated by the country. Moreover, note that most of the oil in the world is traded relative to a benchmark price. Thus, any change in a benchmark price will affect most of the prices in the world. This article aims to study how the prices of three Iraqi oil blends (Basrah Light, Basrah Heavy and Kirkuk) increased or decreased when their corresponding benchmark oil prices increased and decreased. Specifically, how much do these three Iraqi blend prices change when the corresponding benchmark prices increase versus decrease? This will help in understanding the Iraqi oil pricing strategy. When the benchmark oil prices increase, if Iraqi blend prices increase more, and when the benchmark oil prices decrease, if Iraqi blend prices decrease less, then this can be considered a successful strategy. Due to the inelastic demand curve of oil: as oil prices increase, the corresponding total revenue increases, while a decrease results in the corresponding total revenue decreasing. Therefore, when oil prices increase under a successful strategy, then Iraq's total oil revenue increases more than the average of the other oil-producing countries and decrease less if prices drop.

Thus, the question we directly assess the success of the Iraqi oil price strategy. However, the impulse response analyses reported here suggest that positive benchmark oil price shocks increase the prices of major Iraqi blends Basrah Light and Kirkuk less than a negative shock in benchmark prices. The direction of the asymmetry is the reverse for Basra Heavy compared to the other two blends. This shows that Iraq cannot benefit from oil price increases and market developments for Basrah Light and Kirkuk (the two most traded blends). Moreover, as the magnitude of shocks to the benchmark prices increases, the degree of asymmetry increases.

Basrah Light, Basrah Heavy and Kirkuk crude oils, which are the three different types of oil produced by Iraq, are different in their physical/chemical characteristics. Each type of Iraqi crude also has a different demand pattern based on their export destinations and the refinery configurations of importing regions. Thus, Iraq decides its oil prices in U.S. dollars by setting a fixed price margin to a benchmark price for the coming month and may change the margin every month. The margin is set through its Official Selling Prices (OSP) each month for Iraq's long-term customers depending on their geographic locations. Any month's margins can be positive or negative relative to its benchmark price.

A unified world oil market hypothesis assumes a long-run relationship among all the oil prices beyond their physical, technical, political and monetary disruptions. Various researchers and scholars have supported the unified world oil market hypothesis in their studies. Adelman (1984) examines the international oil transactions between Saudi Arabia and the United States by studying the political developments of these two countries from 1971 to 1980. He claims that Saudi Arabia prioritizes its economic interests in setting the crude oil price, creating a common structure that affects the world oil market. Rodriguez and Williams (1993) examine whether there is a long-run relationship among the four major crude blends: West Texas Intermediate (WTI), Brent blend (Brent), Alaskan North Slope and Dubai's Fateh (Dubai) benchmarks. They argue that there is a long-run relationship among those oil prices. Gulen (1997) examines the relationships among the prices of fifteen oil blends by considering their American Petroleum Institute (API) gravities and sulfur content differentiations for the period between 1980 and 1995. By applying the bivariate and multivariate versions of cointegration tests to the formed groups, he argues that the prices of oil types with the same quality content in different production regions do not move together. He claims that this supports the unified world oil market hypothesis. However, in his study, heavy crude oil prices do not move in the same direction. Fattouh (2010) studies crude petroleum price differentials by adopting a two-system threshold autoregressive process. He argues that even if there are two adjustment processes to the long-run equilibrium oil prices, a long-run equilibrium supports the unified oil market hypothesis.

Contrary to the unified world oil market hypothesis, other studies claim the existence of regional oil markets and focus on the relationships between the benchmark prices of different oil types, globally and regionally. International Oil Companies (IOC) and National Oil Companies (NOCs) fiercely compete in the oil markets. They try to differentiate themselves to increase their market shares in different dimensions besides the chemical characteristics of the oils they produce. This differentiation suggests that the hypothesis of the unified world oil market is not valid. Weiner (1991) studies the interactions between different oil types such as Nigerian Bonny Light, Saudi Light, United Kingdom Generic, Indonesia Generic and Soviet Urals in four separate regions from 1980:1 to 1987:4. He concludes that there is a significant level of regionalization and suggests that the world oil market is far from being completely unified. This is because sellers can discriminate oil prices by adopting different calculation formulas depending on export destinations. Kaufmann and Banerjee (2014) also argue that the global oil market is not entirely unified; they claim that crude oil is regionalized because of differences in the physical properties of crudes, country risks, geographical location and OPEC membership. Jia et al. (2015) utilize an optimal wavelet analysis based on a gray correlation between three distinctive benchmark oil prices and the China-Daqing blend with one-to-one and many-to-one dynamics. The findings in that study suggest that a unified oil market does not exist.

Studies that support a regional oil market structure also report that oil prices follow an asymmetric behavior to world oil market benchmarks. Weiner (1991) argues that using several kinds of crude oil in different regions of the world causes oil-producing countries to change their sale prices depending on the region they export to. Moreover, Kaufmann and Banerjee (2014) argue that different factors (such as crude oil specifications, being a member of OPEC, geographical factors and the political structure of the crude oil exporting country) affect oil prices and cause different pricing. To illustrate the effects of different factors, Jia et al. (2015) also study the dynamic relationships between spot Chinese Daqing oil prices and a set of world benchmark oil prices. They support the existence of a regional oil market.

Overall, oil prices remain under the influence of global benchmark prices. Certain factors affect the benchmark prices: chemical characteristics of different types of oil, the political structures of the major oil-producing countries, participation in organizations like OPEC, the region from which the oil is exported and the export destinations for the produced oil. Therefore, regional prices should be more important than global scale prices when determining oil prices.

To the best of our knowledge, Kaufmann and Ullman (2009) and Sahin et al. (2022) are the only studies examining the asymmetric effects of benchmark oil prices on regional/local oil prices. Kaufmann and Ullman (2009) examine the causal relationships among nine crude oils, some of which are benchmark oils. Their model also allows for asymmetry where oil prices are rising versus falling. Sahin et al. (2022) study the effects of benchmark oil prices on Russian oil prices. There are various reasons for asymmetry in the Iraqi case; an increase or decrease in benchmark prices may affect Iraqi blends differently. The nature of production agreements between the Iraqi government and oil (upstream) companies and their inadequate storage facilities lead to the first source of asymmetry. Oil-producing upstream firms mainly have a fixed revenue from their oil production regardless of the oil price. Both government and local producers like to sell as much oil as possible regardless of oil prices. More importantly, Iraq has limited storage capacity. Thus, when the demand is high, they can increase the Iraqi oil prices, but Iraq must decrease oil prices more when the demand is low.

The *r*-factor is the second reason for the asymmetry. Ahmadov et al. (2012) define the *r*-factor as the proportion of aggregate receipts from the sale of petroleum to cumulative expenses. The Iraqi government makes an extraction agreement with an upstream company for a fixed cost per barrel. Thus, the Iraqi government's revenue is based on a sale price determined by *r*-factor per barrel. An X percent increase in the sale price increases government revenues more than X percent, or if the government wants to increase its revenue by Y percent, then oil prices should increase less than Y percent. This triggers the asymmetric response of oil prices to benchmark oil prices. Third, the oil sale revenue constitutes the primary source of income for Iraq and the main source of revenue for the government. If oil prices are lower, then the government must sell more oil, thus reducing its OSP to meet its inflexible revenue needs. This suggests that Iraqi oil prices will be lower with a higher oil supply to meet these revenue needs and will respond differently to an increase versus a decrease in the benchmark oil prices. These three characteristics are not similar to those of Russia and are likely to affect the direction of asymmetry since Russia produces its oil mainly from its own companies and does not have a storage problem. The empirical evidence here suggests that Iraq cannot increase the prices of its two major blends, Basrah Light and Kirkuk, as much as their respective banhmarks suggest when the benchmark oil prices increase but has to decrease the prices of these two major blends more when their respective benchmark oil prices decrease. The reverse is true for Bashrah Heavy. Note that the considerable bulk of Iraqi oil exports consists of Basrah Light and Kirkuk. Thus, this suggests that fluctuations in petroleum price movements do not benefit the Iraqi public but instead cause inefficiencies that harm the Iraqi economy.

The outline of this paper is as follows: section 2 introduces the three types of Iraqi oil and their benchmark specifications, while section 3 discusses Iraqi oils and its other competitors. Section 4 discusses the data and introduces the econometric methodology for assessing the asymmetry. In section 5, empirical evidence is provided. In section 6, we present our results and offer conclusions.

2. THREE TYPES OF IRAQI OIL

Up to 90% of Iraq's proven oil reserves are located in onshore fields in the southern part of the country. The fields in this region are under the control of the Iraqi Federal Government. The remaining 10% of crude oil reserves are located in the northern part of the country and are controlled mainly by the Kurdish Regional Government (KRG). Iraq has three different types of crude oil to be exported: Basrah Light, Basrah Heavy and Kirkuk crude. Basrah Light is the country's main export blend of oil, followed by Basrah Heavy and Kirkuk crude oils. According to the Refinitiv Eikon Data Delivery System, China, India, South Korea, the United States and Italy are the top five countries that imported Iraq's crude oil in 2019. China imported 26.50% of Iraqi oil in 2019, while India, South Korea, the United States and Italy imported 25.03%, 8.10%, 7.86% and 6.25%, respectively. Thus, Asia-based countries are the major buyers of Iraqi crude oils.

Iraq exports two Basrah Blends from the country's Southern Port of Basrah. Basrah Light and Basrah Heavy are sent out from Al Basra Oil Terminal (BOT) and Khor al-Amaya Oil Terminal (KOT). The Kirkuk blend is exported from the Turkish Port at Ceyhan via the Kirkuk-Ceyhan Oil Pipeline. Basrah Light and Basrah Heavy have different physical properties and thus have different product yields, refinery processing costs, technical challenges and buyer patterns. Basrah Light grade has a higher API and lower sulfur content than Basrah Heavy. The API for Basrah Light is 33° and 26.4° for Basrah Heavy. The sulfur level is 2.85% for Basrah Light and 4.12% for Basrah Heavy (S&P Global Commodity Insight, 2022). These differences are reflected in their pricing mechanisms triggered by different demand patterns. They also explain why different asymmetric patterns can be observed for two crude blends produced in the same region and exported from the same port. Note that crude oil prices are mainly affected by the margins of the oil products refined from that crude oil. The market opportunities for Basrah Heavy are more limited than other Iraqi oil types due to its lower API and higher sulfur content. A less preferred oil will have a more elastic demand, so one may expect a higher benchmark crude oil price increase to affect the Basrah Heavy prices more than a benchmark crude oil price decrease.[1]

The Kirkuk crude oil blend has a 35° API and a 2.4% sulfur rate, making it lighter and sweeter than the other two Basrah blends. Kirkuk crude oil is produced from three blocks: Khurmala Dome, Avana Dome and Baba Dome in the northern part of the country. The Avana Dome and Baba Dome blocks belong to the Iraqi Federal Government. Khurmala Dome belongs to the KRG. The operational responsibility of Kirkuk crude oil belongs to KRG, but the Federal Administration holds various other rights. Both the KRG and the Federal Administration produce the Kirkuk Blend. While the KRG is responsible for shipping, sales, and determining buyers of the Kirkuk blend, Iraq's State Organization for Marketing of Oil (SOMO) determines the price of the Kirkuk blend. It allocates revenue from exports to the KRG and the Federal Administration. One of the reasons why Iraqi oil is exported from the Turkish Ceyhan port is that shipment to a Basrah port would be more costly. Secondly, the Strait of Hormuz and the Suez Canal are bypassed with the export of Kirkuk crude oil from the Ceyhan port, which provides direct access to the Mediterranean market.

OSPs are a crucial element for crude oil exports. OSPs are set at a fixed price margin relative to a benchmark by NOCs. These fixed margins are set for a whole month after a formal meeting. SOMO sets these fixed margins in U.S. dollars to determine OSPs for all Iraqi

1. Kaufmann (2016) studies different types of oils including Basrah Light and Kirkuk and argues that "*sulfur content, density, distance between supply ports, and OPEC membership confirm the importance of oil supply choke points, OPEC's ability to influence prices, and differences in refinery technology*" are important for the price differentiation.

blends for each month, and they may change every month. Brent and Dubai are the most broadly utilized benchmarks worldwide; however, the Dubai price has been one of the main reference prices for crude oil shipped from the Middle East to Asia since the 1980s. Iraq uses Brent for its European crude oil shipments, Oman/Dubai for its Asian shipments and the Argus Sour Crude Index as the corresponding benchmark for American shipments for all three blends it exports.

3. IRAQI OIL AND OTHER COMPETITORS

Although Iraq is one of the major oil exporters in the world and a member of OPEC, this does not prevent the country from facing fierce competition for its market share, especially with its OPEC allies Iran, Kuwait, Saudi Arabia and the United Arab Emirates – its major competitors. Asia has been the critical region in driving global oil demand. Nearly all major oil producers compete intensely to keep or increase their market shares in Asia. This is a major conflicting interest among OPEC members as they all want to attain a higher market share in Asia while trying to keep OPEC as a working alliance against their non-OPEC counterparts. Saudi Arabia, being the largest producer and exporter to the region, is the leading country in driving the pricing mechanism for crude oil exported from the Middle East to Asia. In other words, Saudi Arabia's Asian OSPs for its crude grades are the leading price setter for all other Middle Eastern crude oil shipped to Asian markets.

Saudi Arabia's main export grade, Arabian Light, competes directly with Iraqi Basrah Light. This forces Basrah Light to converge its prices to Arabian Light prices instead of following its own dynamics. Basrah Light needs to adjust its OSP against Arabian Light to find buyers, which can be an additional factor in determining the OSPs and the benchmark prices. Thus, as both crude grades are priced relative to the Dubai benchmark for Asian OSPs, Basrah Light's OSP is generally set lower against Arabian Light's OSP to gain an advantage in sales.

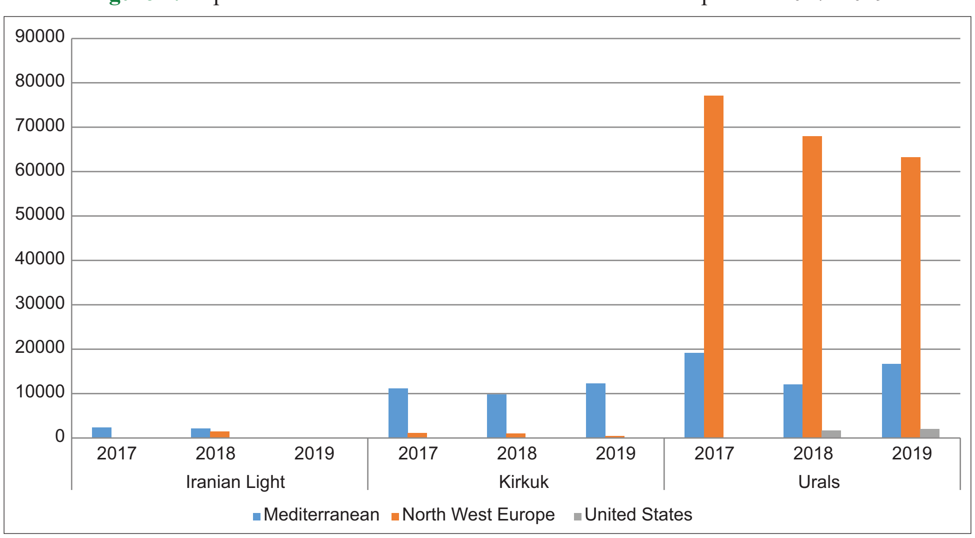
Basrah Heavy also competes with other Middle Eastern crude grades for its market share, but its lower API grade and higher sulfur content are its major disadvantages. Higher API simplifies the refining process, but high sulfur content is an undesired specification in the oil market, as it increases transportation and refining costs and harms the equipment during the shipment and refining of crude oil. With its increased total volume, Basrah Heavy must incorporate these costs and potential risks for its buyers to find buyers in the market. This results in a more than desired discount for the crude grade with potential financial losses for the Iraqi government due to market conditions. Despite its physical disadvantages, Basrah Heavy can find enough buyers in the market during high-demand periods thanks to its large export capacity, especially in Europe and Asia, where refineries can process high-sulfur oil relatively successfully. The Iraqi government tends to increase its Basrah Heavy OSPs more than the increase in their benchmarks during strong demand periods to cover the losses due to the deductions mentioned above in low demand periods. This may lead to a different asymmetric pattern for Basrah Heavy compared to Basrah Light and Kirkuk.

Potential competitors of Kirkuk crude oil are the Urals and Iranian Light. Kirkuk's crude oil export destinations are the Mediterranean, Europe and the United States. Ceyhan provides an advantage for the blend to be sold to the Mediterranean and the U.S. since this type of Iraqi oil does not need to pass through the Strait of Hormuz and the Suez Canal. Although Kirkuk crude oil has an advantage in shipment, it generally has a lower market share than its competitors. Figure 1 shows Kirkuk Blend's market share compared to its potential competitors from 2017 to 2019. When the market shares are examined, it is clear that the Russian Urals crude oil puts pressure on the target markets of the Kirkuk Blend. However, terrorist attacks on the production facilities may cause supply disruption, leading to the Kirkuk blend being priced lower.

4. DATA AND METHODOLOGY

The monthly data employed is from October 2002 for the Basrah Light and Kirkuk blends and from April 2015 for Basrah Heavy. The later date for Basrah Heavy is due to the blend's introduction.

Figure 1: Export Destinations of Kirkuk Crude Oil and its Competitors 2017–2019



Source: Refinitiv Eikon Data Delivery System (Authors' Calculations)

Our analyses use European, Far East and U.S. deliveries of Basrah Light and Basrah Heavy blends and Europe and U.S. deliveries of Kirkuk blend. Thus, we use eight series for Iraqi oil in our analyses. The world oil demand due to lower transportation and industrial demand was changed considerably with the COVID-19 Pandemic. In order to eliminate these extraordinary circumstances, we ended the sample in October 2019. Data for benchmark prices and Iraqi oil prices are gathered from Refinitiv Eikon Data Delivery System. The price data for Iraqi oil prices and benchmark prices are reported in U.S. dollars and oil price data are divided by the United States Consumer Price Index to convert them into real terms. The Federal Reserve Bank of St. Louis (FRED) data delivery system obtains the consumer price index. Three benchmarks are employed, depending on their export destinations. Dated Brent (DBrent) is used for all European sales for all three blends. For Asia sales, the Oman-Dubai average is used as the benchmark. The Argus Sour Crude Index is used for U.S. sales by SOMO; however, since this data is not readily available, the Reuters Sour Crude Index (RSCI) data has been used as a benchmark for U.S. sales in our analyses. Even if it is not possible to calculate the discount for the U.S. markets, for the sample that we consider, Basrah Light is sold at a 4.66 USD discount for European markets and 0.93 USD for the Asian markets, and Basrah Heavy is sold at a 7.58 USD discount for the European markets and 4.59 USD for the Asian markets, while Kirkuk is sold at a discount of 3.61 USD for the European markets compared to their respective benchmarks.

To analyze the dynamic asymmetrical relationship between each of the Iraqi blend prices and benchmark oil prices in the study, following Azad and Serletis (2022), Sadath and Acharya (2021), Sahin (2021) and Zulfigarov and Neuenkirch (2020), the Kilian and Vigfusson's (2011) methodology is used. This is the only method which allows the time-varying asymmetry to be estimated for consecutive periods. The two-variable non-linear VAR (n) specification adopted is the following:

$$y_t = \beta_{10} + \sum_{k=1}^{n} \beta_{11,k} y_{t-k} + \sum_{k=1}^{n} \beta_{12,k} x_{t-k} + \varepsilon_{1,t} \quad (1.a)$$

$$x_t = \beta_{20} + \sum_{k=0}^{n} \beta_{21,k} y_{t-k} + \sum_{k=1}^{n} \beta_{22,k} x_{t-k} + \sum_{k=0}^{n} \gamma_{21,k} y_{t-k}^{+} + \varepsilon_{2,t}\ , \quad (1.b)$$

where $t = 1, 2,\ldots, T$

Here, y_t is the logarithmic first difference of benchmark oil price and x_t is the logarithmic first difference of the different types of Iraqi oil that we consider; $\varepsilon_{1,t}$ and $\varepsilon_{2,t}$ are the mean zero sequentially uncorrelated error terms at time t and n is the lag order. Here the logarithmic first differences are taken as a percentage change of the variable of interest. Note that equation (1.a) is a standard (symmetric) linear model specification both in y_t and x_t, while equation (1.b) includes benchmark oil price changes, Iraqi oil type price (x_t) and the censored variable of y_t at the same time. The censored variable y_t^+ is for the positive changes in the benchmark oil price, which is defined as:

$$y_t^+ = \begin{cases} y_t, \ if\ y_t > 0 \\ 0, \ if\ y_t \le 0 \end{cases} \quad (2)$$

β_{10} and β_{20} are for the intercept terms in the benchmark and Iraqi crude oil price specifications, respectively. $\beta_{11,k}$ and $\beta_{12,k}$ are for the estimated coefficients of the lag values of the benchmark oil prices and the Iraqi crude prices in the benchmark oil specification. $\beta_{21,k}$ and $\beta_{22,k}$ are for the estimated coefficients of the lagged values of the benchmark oil prices and Iraqi crude prices in the Iraqi crude oil price specification. Lastly, $\gamma_{21,k}$ is for the estimated coefficients of the censored variable in the benchmark oil price. Note that incorporating y_{t-k}^+ as an additional regressor in equation (1.b) allows for the positive values of y_{t-k} having a different effect than the negative values of y_{t-k}. If y_{t-k} is negative, then the effect of y_{t-k} on x_t will be $\beta_{21,k}$ but if y_{t-k} is positive, its effect will be $\beta_{21,k} + \gamma_{21,k}$. Thus, if $\gamma_{21,k}$ is zero, then this suggests that there is no difference between the positive and negative values of y_{t-k}.[2]

We assume that benchmark crude oil prices affect Iraqi crude blends but not vice versa contemporaneously. However, all the variables affect each other with a lag. The method has several advantages. Compared to structural models, the VAR methodology allows for capturing the dynamic relationship between oil prices with a few parameters. Moreover, the introduced asymmetry allows us to assess how the increase versus decrease in benchmark prices affects Iraqi oil prices differently.

In order to test the asymmetry, we first used a slope-based test which has a χ^2_{n+1} distribution under the null hypothesis that H_0: $\gamma_{21,0} = \ldots = \gamma_{21,n} = 0$ in equation (1.b). Second, we used Kilian and Vigfusson's (2011) impulse response-based test for asymmetry. Note that the impulse responses are a non-linear model and also history-dependent, and the magnitude of the shocks changes the slope of the impulse response function (see, for example, Berument et al., 2011). Thus, these tests are performed if $I_y(h,\delta) = -I_y(h,-\delta)$ or $I_y(h,\delta) + -I_y(h,-\delta) = 0$ where h is the response period $h = 1, 2,\ldots, H$ and δ is the magnitude of introduced shock such of 1-SD or 2-SD shocks.

Table 1 reports the unit root and stationarity tests for the variables we employ in the analyses. The null hypothesis is the stationarity for the KPSS test and the unit root for the rest of the tests. Panel A reports the test statistics with the intercept term, while Panel B reports the statistics with the intercept term and the time trend. Panel C reports the test statistics for the first differences of the series with a constant term. The estimates suggest that all the series are stationary except the Basrah Heavy blend for different destinations. Since the Iraqi economy has been subject to various economic shocks, Panel D reports the test with a structural break. Only Basrah Heavy for the Far East (F.E.) deliveries seems stationary. These tests might be subject to *type-I* error. Thus, we test if there is a stable long-run

2. Note that the current value of the benchmark oil prices do affect Iraqi oil prices but not vice versa. This makes sense because Iraq is a major player in the world oil market. Thus, both the Iraqi OSP margin announcements made before the corresponding month affect benchmark oil prices and the benchmark oil prices ultimately affect Iraqi oil selling prices. However, once the announcement is made for the coming month, Iraqi oil prices should be affected by the benchmark prices contemporaneously. Note that Iraqi crude oil prices are set relative to a benchmark crude oil price depending on their respective destinations. The purpose of this paper is to determine how benchmark crude oil prices affect Iraqi Oil prices (i.e., Benhmark+Fixed margin). Thus, we employ the bi-variate analyses.

Table 1: Unit Root and Stationary Tests

Tests	Basrah Light E	Basrah Light U.S.	Basrah Light F.E.	Basrah Heavy E	Basrah Heavy F.E.	Basrah Heavy U.S.	Kirkuk E	Kirkuk U.S.	DBrent	Oman/Dubai	RSCI
Panel A: Intercept											
DF	−1.477	−1.356	−1.698*	−3.325***	−2.857***	−1.904*	−1.466	−1.556	−1.847*	−1.092	−0.802
ADF	−2.541	−3.003**	−2.882**	−3.531***	−3.044**	−3.151**	−3.038**	−2.998**	−2.135	−2.145	−1.34
PP	−2.332	−2.169	−2.204	−2.728*	−2.145	−2.285*	−2.226	−2.312	−1.79	−2.295	−1.225
ERSP	5.895	5.172	4.798	1.32***	1.733***	2.115**	4.319	5.896	3.669*	12.325	11.53
NG−P	−1.497	−1.373	−1.682*	−3.258***	−2.894***	−1.966*	−1.487	−1.533	−1.85*	−1.079	−0.767
KPSS	0.348	0.347	0.337*	0.182	0.24	0.225	0.343*	0.339	1.336	0.346	0.903***
Panel B: Intercept and Trend											
DF	−1.855	−1.671	−2.102	−3.44**	−2.952*	−2.93*	−1.8	−2.01	−2.417	−1.254	−2.262
ADF	−2.535	−2.995	−2.86	−3.515**	−3.107	−2.387	−3.039*	−2.992	−2.372*	−2.136	−2.351
PP	−2.22	−2.066	−2.091	−2.708	−2.159	−2.315	−2.129	−2.213	−1.917	−2.206	−2.474
ERSP	12.832	11.1	10.778	4.029***	5.263*	9.657	9.685	12.079	7.654	24.354	8.698
NG−P	−1.87	−1.693	−2.098	−3.345***	−2.951**	−2.886*	−1.821	−1.983	−2.429	−1.23	−2.292
KPSS	0.348*	0.347***	0.338***	0.175**	0.174**	0.172**	0.342***	0.339***	0.309***	0.346***	0.157**
Panel C: First Difference With Intercept											
DF	−2.83***	−2.618***	−7.206***	−6.827***	−5.275***	−6.534***	−2.874***	−7.025***	−14.111***	−6.37***	−8.523***
ADF	−11.172***	−10.26***	−10.052***	−6.84***	−5.334***	−6.576***	−10.79***	−10.629***	−14.919***	−13.36***	−8.861***
PP	−12.085***	−10.194***	−9.393***	−7.719***	−4.906***	−5.778***	−11.344***	−10.116***	−14.538***	−13.307 ***	−12.426***
ERSP	0.317***	0.419***	0.475***	0.415***	0.916***	0.414***	0.326***	0.539***	0.158***	0.381 ***	0.245***
NG−P	−2.469**	−2.364**	−5.877***	−5.361***	−3.702***	−5.403***	−2.529**	−5.718***	−9.025***	−5.322 ***	−7.002***
KPSS	0.237	0.224	0.197	0.13	0.103	0.107	0.219	0.214	0.114	0.245	0.096
Panel D: Unit Root Test with a Break											
Level	−3.284*	−2.906	−2.817	−2.985	−3.686**	−3.738**	−3.032	−2.784	−3.315*	−1.915	−2.179
Inter and Trent	−3.954*	−3.657	−3.499	−3.306	−3.768*	−3.903*	−3.727	−3.558	−3.482	−2.567	−4.347**
First Difference	−11.679***	−10.763***	−9.672***	−7.066***	−5.329***	−6.203***	−11.325***	−10.725***	−14.885***	−11.054***	−8.619***

*,** and ***Indicate the level of significance at 1%, 5% and 10%

relationship between the variables of interest. Table 2 reports the Phillips-Ouliaris Cointegration Test. We fail to reject that there is no cointegrating relationship between each Iraqi oil that we consider depending on its respective destination and its corresponding benchmark. Thus, our specifications are valid.

5. EMPIRICAL EVIDENCE

Kilian and Vigfusson's (2011) specification is estimated with two lags, as suggested by the Bayesian information criteria for the analyses (Table 3). Panel A of Table 4 reports the Slope Based test for asymmetry; thus, we tested all the coefficients of $\{y_{t-i}^{+}\}_{i=0}^{n}$ jointly to be zero. We reject the null of symmetry at the 1% level for all the export destinations. This is parallel to Kaufmann and Ullman (2009), which considered a set of North American, European, African and Middle Eastern oils as well as Sahin et al. (2022), which studied only the Russian oils. Panel B also reports the impulse-response-based test for 1-SD and 2-SD shocks for each impulse response period considered.[3] Even if the statistical evidence is weaker for the latter asymmetry tests, the symmetry is clearly rejected for the major export destination (Far East) for the major export blend (Basrah Light). Thus, we claim that the effects of benchmark oil prices on Iraqi crude prices are asymmetric.

Figures 2-4 report the impulse responses of three Iraqi crude blends to benchmark positive and negative oil price shocks by different 1-, 2-, 4-, and 10- S.D. shocks. Even if it is not common to report the analyses with 4- and 10- S.D. shocks, these additional analyses allow us to observe if the magnitude of the shocks affects the degree of asymmetry. These impulses are reported for 12 periods. The solid black lines are for a positive benchmark price shock, whereas the dotted lines are for negative price shocks.[4] However, to compare the magnitudes, we plot the inverse (negative) of the negative benchmark shocks, and all the impulse responses were also normalized with 1-SD shock so that the magnitudes could be compared easily.

Figure 2 reports the impulse responses of positive and negative shocks of the benchmark of oil prices and their effects on the oil prices of Basrah Light oil according to their export destinations. *Basrah Light E* is for Basrah Light's European destination, *Basrah Light U.S.* for its U.S. destination, and *Basrah Light F.E.* is for its Asian destination. *Basrah Light E* uses the *DBrent* as its benchmark price, while *Basrah Light U.S.* uses the *RSCI* and *Basrah Light F.E.* uses the *Oman/Dubai.*

The responses of *Basrah Light E* to negative 1-, 2-, 4- and 10- S.D. shocks to *DBrent's* are greater than their positive shocks in absolute values for all the periods. After the first period, the positive and negative shocks move in the opposite direction, but as the shock magnitude increases, the difference between positive and negative gradually increases. When 1-, 2-, 4- and 10- S.D. shocks are given to *Oman/Dubai*, the effects of the negative shocks are greater than those of the positive shocks for *Basrah Light F.E.* after the second period. The effects of the negative shocks for *Basrah Light F.E.* are observed in the initial level only for 4- and 10-SD shocks. Impulse responses change the direction of the effects after the first period, which is statistically significant for both 1-SD and 2-SD shocks at the 5% and 1% levels. For *Basrah Light U.S.*, the effects of 1-SD are positive and negative to the *RSCI* benchmark price, the negative shocks have greater effects on prices compared to the positive shock for all the periods that we consider. However, for the 2-, 4-, and 10- S.D. shocks, the effects of negative shocks are higher than positive shocks after the first period until the 4th period. After the *4th* period, the magnitude of the shock changes direction. The effects of positive shocks are greater than those of negative shocks.

Figure 3 reports that the impulse responses of positive and negative shocks to the benchmarks of oil prices and the effects of the three kinds of Basrah Heavy on oil prices depend on their export

3. We also perform the 4-SD and 10-SD shocks-based tests. These are not reported to save space. However, they are available upon request from the authors.
4. Following Kilian and Vigfusson (2011), the impulses are calculated by Monte Carlo integration over 300 histories with 10,000 paths for each shock.

Table 2: Phillips−Ouliaris Cointegration Test

Basrah Light E−Dbrent	Basrah light U.S. − RSCI	Basrah Light F.E. − Oman/Dubai	Basrah Heavy E−Dbrent	Basrah Heavy F.E. − Oman/Dubai	Basrah Heavy U.S. − RSCI	Kirkuk E−Dbrent	Kirkuk U.S. − RSCI
−8.313***	−6.817***	−11.475***	−4.427***	−4.702***	−6.328***	−8.954***	−6.034***

***Indicates the level of significance at 1%

Table 3: Lag Order Selection: Schwarz Information Criterion

Lags	Basrah E	Basrah F.E.	Basrah U.S.	Basrah Heavy E	Basrah Heavy F.E.	Basrah Heavy U.S.	Kirkuk E	Kirkuk U.S
0	−2.059	−2.119	−3.960	−1.569	−3.194	−3.299	−2.714	−3.221
1	−5.206	−4.909	−6.973	−3.096	−5.350	−5.763	−5.806	−6.545
2	−5.387*	−5.105*	−7.532*	−3.504*	−5.574*	−6.831*	−6.025*	−6.975*
3	−5.332	−5.020	−7.408	−3.250	−5.485	−6.641	−5.948	−6.870
4	−5.261	−4.953	−7.272	−3.005	−5.342	−6.439	−5.891	−6.771
5	−5.175	−4.866	−7.126	−2.768	−5.071	−6.297	−5.810	−6.621
6	−5.085	−4.770	−6.964	−2.598	−4.885	−6.056	−5.714	−6.458
7	−5.020	−4.680	−6.792	−2.329	−4.645	−5.909	−5.683	−6.389
8	−4.966	−4.590	−6.633	−2.168	−4.421	−5.752	−5.626	−6.233
9	−4.874	−4.500	−6.486	−1.893	−4.143	−5.610	−5.530	−6.112
10	−4.775	−4.399	−6.358	−1.731	−3.974	−5.431	−5.428	−5.992
11	−4.689	−4.317	−6.270	−1.529	−3.726	−5.185	−5.338	−5.881
12	−4.619	−4.218	−6.156	−1.266	−3.467	−4.935	−5.244	−5.747

*Is for the optimum lag order

Table 4: Testing symmetry in oil price increases and decreases

Tests	Basrah Light E		Basrah Light F.E.		Basrah Light U.S.		Basrah Heavy E		Basrah Heavy F.E.		Basrah Heavy U.S.		Kirkuk E		Kirkuk U.S.	
	Panel A: Slope based test (test statistics)															
Wald Test	6358.2**		5693.5**		31645.0**		5035.3**		11102.0**		28589.7**		18969.0**		84982.6**	
	Panel B: Impulse Response Based Test [p−values]															
Period	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**	**1−SD Shock**	**2−SD Shock**
0	0.778	0.615	0.131	0.100	0.793	0.042*	0.393	0.192	0.220	0.143	0.657	0.105	0.749	0.161	0.887	0.204
1	0.182	0.259	0.048*	0.004**	0.166	0.097	0.694	0.426	0.322	0.294	0.875	0.267	0.014*	0.041*	0.362	0.417
2	0.258	0.369	0.006**	0.000**	0.168	0.173	0.672	0.619	0.088	0.237	0.524	0.419	0.036*	0.091	0.291	0.431
3	0.402	0.533	0.005**	0.000**	0.282	0.256	0.817	0.775	0.088	0.310	0.685	0.571	0.069	0.156	0.422	0.523
4	0.545	0.676	0.009**	0.000**	0.396	0.354	0.904	0.877	0.111	0.338	0.809	0.710	0.120	0.247	0.526	0.651
5	0.672	0.789	0.017*	0.000**	0.514	0.477	0.954	0.937	0.175	0.410	0.892	0.816	0.188	0.354	0.650	0.766
6	0.776	0.870	0.024*	0.001**	0.631	0.593	0.979	0.969	0.225	0.342	0.942	0.888	0.270	0.462	0.757	0.851
7	0.848	0.920	0.040*	0.001**	0.728	0.688	0.991	0.986	0.309	0.438	0.971	0.935	0.363	0.570	0.837	0.909
8	0.905	0.954	0.063	0.002**	0.810	0.776	0.996	0.994	0.386	0.523	0.985	0.964	0.458	0.669	0.896	0.948
9	0.942	0.975	0.092	0.004**	0.870	0.841	0.999	0.997	0.478	0.614	0.993	0.981	0.553	0.754	0.933	0.967
10	0.966	0.987	0.130	0.006**	0.915	0.893	0.999	0.999	0.560	0.695	0.996	0.990	0.642	0.822	0.958	0.981
11	0.981	0.994	0.177	0.010*	0.947	0.928	1.000	1.000	0.644	0.768	0.998	0.995	0.721	0.876	0.976	0.990

In Panel B, the P−value is based on 1000 simulations of the model $\chi^2_{\mathcal{H}+1}$ value. **Indicates the level of significance at 1%. *Indicates the level of significance at 5%

destinations. *Basrah Heavy E*, *Basrah Heavy F.E.* and *Basrah Heavy U.S.* benchmarks *DBrent*, *Oman/Dubai* and *RSCI*, respectively. In the first column of Figure 3, 1-, 2-, 4- and 10- S.D. positive and negative shocks are given to *DBrent* prices, and the effects of the positive shocks on *Basrah Heavy E* for all periods are greater than the negative shocks and the difference increases with the magnitude of the shocks. While there is a rapid increase (decrease) in the first period, after the 1st period, the rapid increase (decrease) with positive (negative) shocks continues to decrease until the 3*rd*. The effects of Oman/Dubai price shocks on Basrah Heavy F.E. are examined in the second column. Similar to Dated Brent shocks, positive benchmark shocks increase Basrah Heavy prices more than negative benchmark shocks decrease Basrah Heavy prices.

The higher the magnitude of the shocks is, the higher the asymmetry is. The effects on *Basrah Heavy U.S.* prices are examined in the third column of Figure 3; the estimates are robust compared to the estimates in the first two columns. Note that even if the slope-based test decisively rejects the null of symmetry, the impulse response-based test cannot reject the null of symmetry. For both Basrah Light and Kirkuk blends, the slope-based tests are statistically significant at 5%, and the Impulse-Response Based test results for 1-SD and 2-SD shocks reject the null of symmetry. One reason is that our sample starts later, and we do not have long data points for Basrah Heavy. More importantly, despite its high sulfur content and thus less desirability, Basrah Heavy has been imported by Asian and European customers due to their refinery configurations. As world oil demands increase, the demand for Basrah Heavy and its price increase even more. This may lead to a different asymmetry pattern for Basrah Heavy than Basrah Light.

Figure 4 reports the effect of positive and negative shocks to the benchmarks of oil prices on Kirkuk oil. Two destinations are considered for Kirkuk: European (*Kirkuk E*) and U.S. (*Kirkuk U.S.*). Their respective benchmarks are *DBrent* and *RSCI*. The first column of Figure 4 shows the response of *Kirkuk E* to the 1-, 2-, 4- and 10- S.D. shocks given to the *DBrent* price. The negative shocks to *DBrent* decrease *Kirkuk E* more than positive shocks increase it after the first period. As the previous analyses reveal, the degree of asymmetry increases with the magnitude of the shocks. However, after the third period, the degree of asymmetry decreases. The second column of Figure 4 assesses the effects of positive and negative shocks to RSCI on Kirkuk U.S. When a 1-SD shock is given to the *RSCI* prices, the effect of a positive shock is greater than that of a negative shock. However, when 2-, 4, and 10-SD shocks are given, the effects of negative shocks are greater than positive shocks between the 1st and 3rd periods. These effects are statistically significant with the slope-based tests, yet also statistically significant for the European deliveries between the 1st and 2nd periods.[5]

5. Iraqi Oil prices are set within a fixed margin to benchmark oil prices. Even if this margin is fixed for a given month, it changes from month to month. The purchasing power or service change for processing Iraqi oil is not the same when the general price level is high versus low. Thus, we deflate all the oil prices with the US CPI level. However, we also repeat the exercises without deflating the oil prices (not reported here but available from the authors upon request). Even if the impulse responses are virtually unchanged, the difference between positive and negative shocks tends to have a lower level of significance, possibly due to heteroskedasticity. Thus, these further support our specifications.

Figure 2: Responses of Basrah Light Prices to Positive and Negative Benchmark Oil Price Shocks by Different Shock Sizes

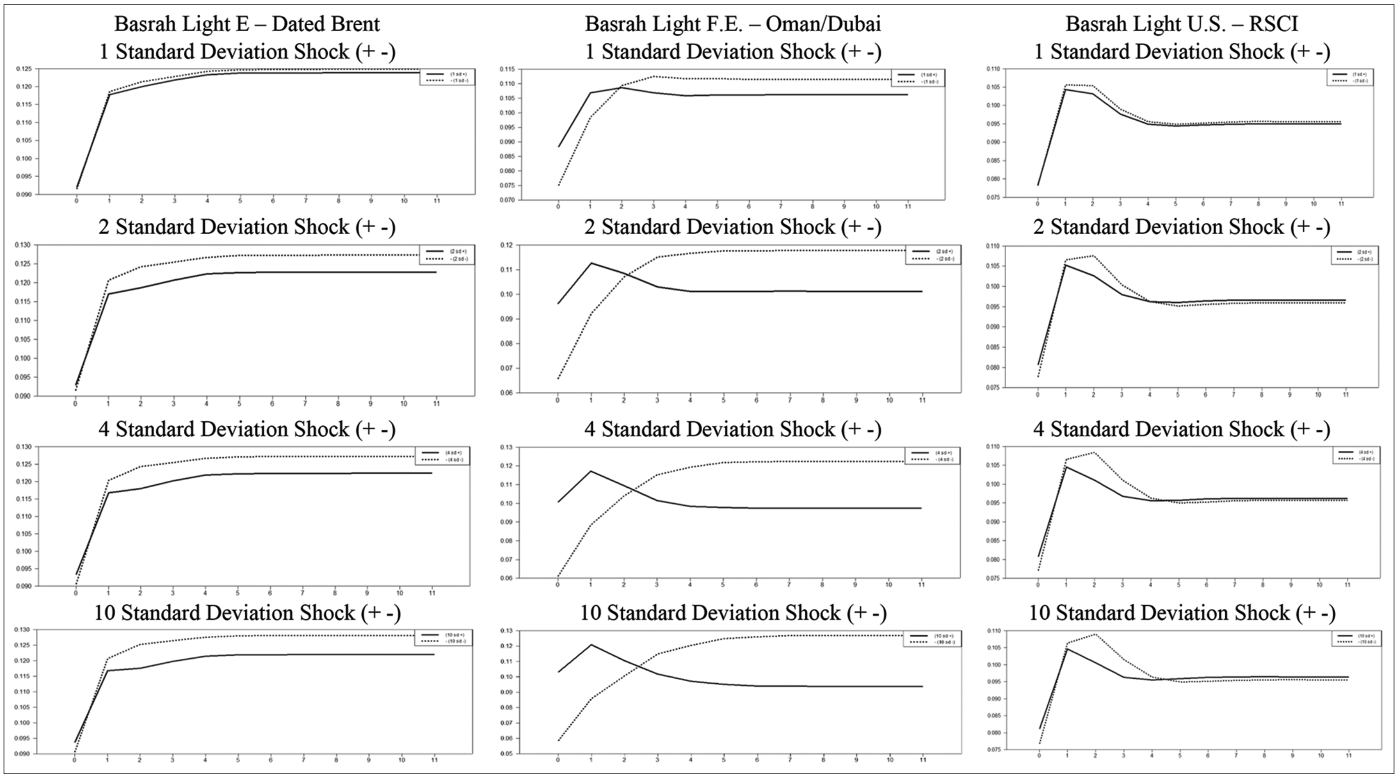
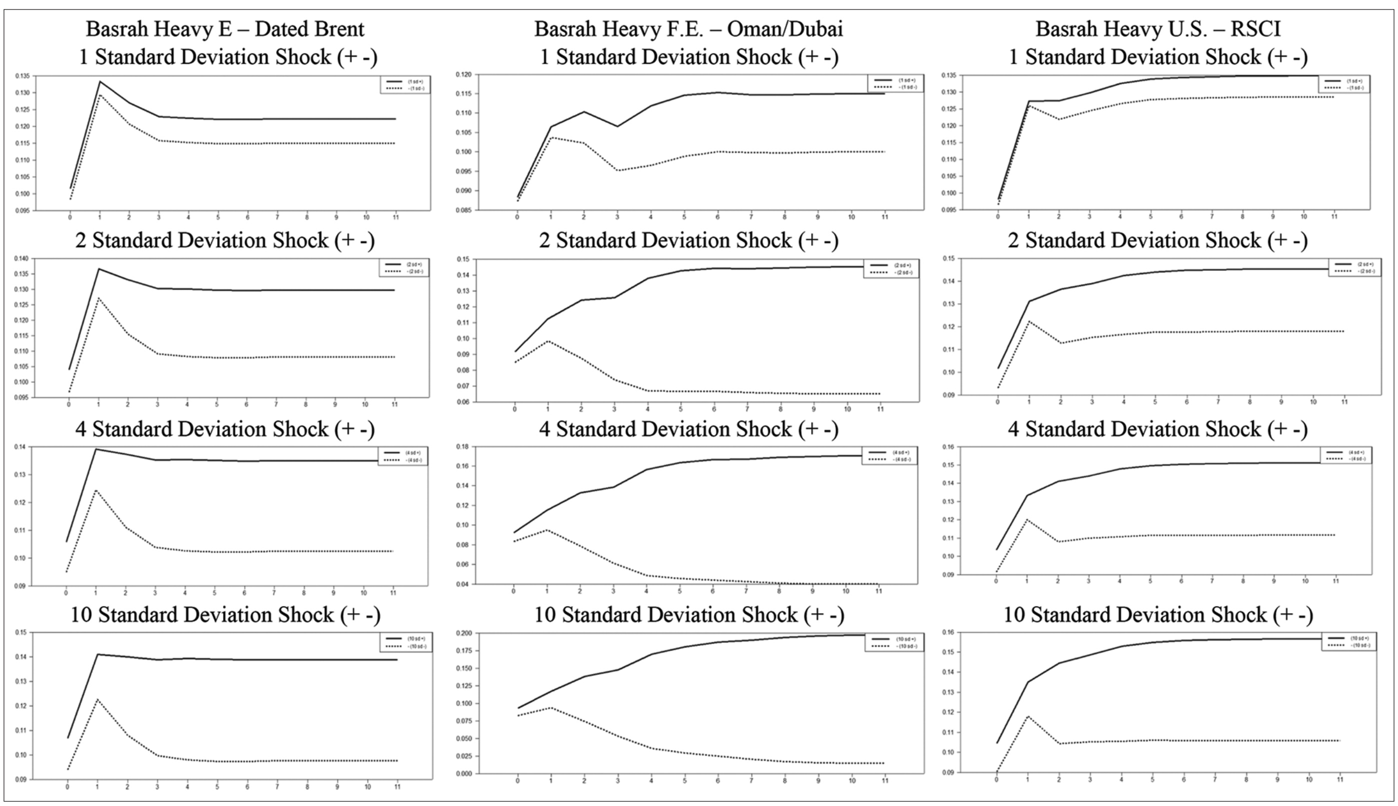


Figure 3: Responses of Basrah Heavy Prices to Positive and Negative Benchmark Oil Price Shocks by Different Shock Sizes



Statistics in Table 1 indicate that the time series for oil prices are non-stationary, and Table 2 suggests that the pairwise relationships are cointegrated. However, the specifications that we employ capture the short-run relationships; in other words, the results represent how a short-run change in a benchmark crude oil generates a short-run change in Iraqi crude. Furthermore, the methodology does not identify causal relationships between prices. Thus, following the methodology that Kaufmann and

Figure 4: Responses of Kirkuk Oil Prices to Positive and Negative Benchmark Oil Price Shocks by Different Shock Sizes

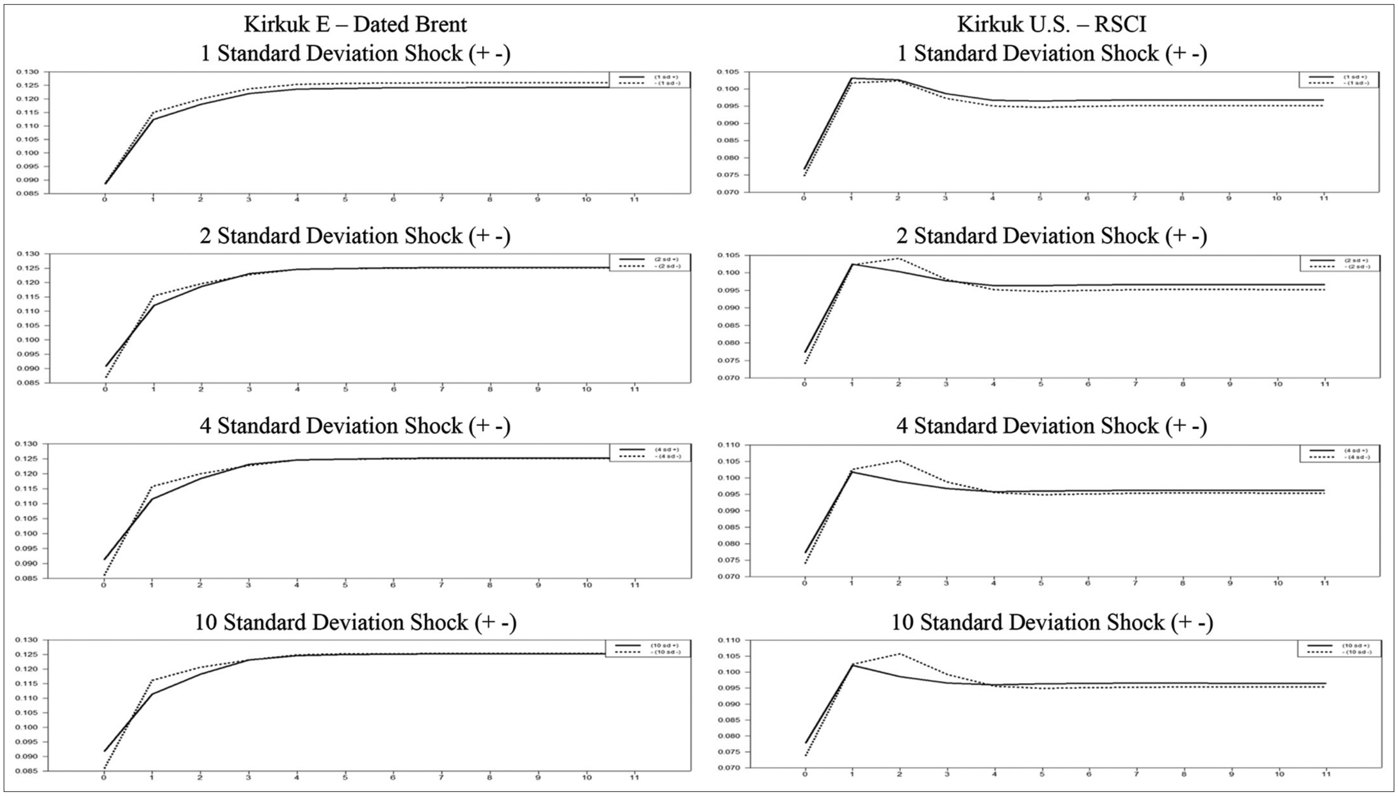


Table 5: The asymmetry test statsitics and their P−values

Basra Light E	Basrah Light F.E.	Basra Light U.S.	Basrah Heavy E	Basrah Heavy F.E.	Basrah Heavy U.S.	Kirkuk E	Kirkuk US
Asymmetry test (P−values)							
25.859	10.449	657.922	5.350	8.633	452.249	71.985	562.859
[0.00]	[0.00]	[0.00]	[0.02]	[0.00]	[0.00]	[0.00]	[0.00]
Granger Causality Test if Benchmark Preceeds Iraqi Oil Blends							
1.865	18.776	1.831	2.363	68.487	1.111	1.937	9.046
[0.01]	[0.00]	[0.02]	[0.00]	[0.00]	[0.33]	[0.01]	[0.00]
Granger Causality Test if Iraqi Oil Blends Preceeds Bbechark							
19.740	2.291	120.389	11.900	1.514	179.990	39.329	11.917
[0.00]	[0.00]	[0.00]	[0.00]	[0.07]	[0.00]	[0.00]	[0.00]

P−values are reported in brackets just after the test statistics

Ullman (2009) employed, we estimate cointegrating relationships between the price level of a benchmark crude and the price level of the Iraqi crude using dynamic ordinary least squares (Stock and Watson, 1993). The residuals from this cointegration are decomposed according to changes in the price of the benchmark crude – positive versus negative (Granger and Lee, 1989). These decomposed residuals are specified in an error correction model that uses the first difference of the Iraqi crude oil prices as the dependent variable. The null hypothesis that the regression coefficients on these decomposed residuals are equal can be tested to evaluate whether there are asymmetries in the relationship between the prices for the two crude oils. Table 5 suggests the presence of asymmetry for all the pairs considered. We also perform the Granger Causality test that Kaufmann and Ullman (2009) proposed. Parallel with our assumption that variables affect each other with a lag, we were able to mostly reject the null that each variable does not affect the others. The empirical evidence on asymmetry that we report here is parallel to Kaufmann and Ullman (2009) and Sahin et al. (2022). Neither of these studies considers any of the Iraqi oils.

6. CONCLUSION

In this paper, we have examined the asymmetric responses of the three different oil types produced in Iraq (Basrah Light, Basrah Heavy and Kirkuk blends) to their respective benchmarks depending on their export destinations. We employed three different benchmarks: Dated Brent for the European markets, Oman/Dubai average for the Asian markets and Reuters Sour Crude Index for the American markets. The empirical evidence suggests positive shocks increase Basrah Light and Kirkuk oil prices less than negative shocks change (decrease) them. Moreover, as the magnitude of the shock increases, the degree of asymmetry increases. However, the asymmetric behavior of Basrah Heavy is the reverse. Sahin et al. (2022) study the asymmetric effect of benchmark oil price changes on individual oil prices, but they study the responses of Russian oils. They report the asymmetry for European deliveries of Russian oil, but the effect of positive shocks was greater than negative shocks. This suggests that Russian oil price-setting strategies for European/Mediterranean deliveries are more successful than the Iraqi deliveries for Basrah Light and Kirkuk. Moreover, our finding on the existence of asymmetry, in general, is parallel to Mork (1989), Hamilton (2003), Kaufmann and Ullman (2009), Haliloglu and Berument (2021) and Azad and Sertelis (2022).

When the price dynamics of Basrah Light, Basrah Heavy and Kirkuk oils are compared with the benchmark prices, they are exported from different locations, face different demand and supply dynamics and have different chemical characteristics. Basrah Heavy's asymmetric behavior differs from the other two Iraqi blends. Basrah Heavy has one major disadvantage regarding its quality: its high sulfur content is an undesirable feature in the oil market that increases shipping and refining costs. Moreover, equipment can be damaged during the transportation and refining of this crude oil blend. Thus, Basrah Heavy's position in the crude oil market is limited compared to that of Basra Light and Kirkuk oils. Due to this limitation and its lower demand, Basrah Heavy is priced lower than other Iraqi oil blends. Therefore, higher demand affects Basrah Heavy prices more than the others. This is what was expected and what was found: the asymmetric pattern of Basrah Heavy is different from the other two Iraqi blends.

The various reasons we consider for the asymmetry are the characteristics of the types of oil that Iraq exports, the export destinations of these oils, production and transportation costs and the refinery production procedures of the importing destinations. The existence of asymmetry for the major Iraqi export blends, Basrah Light and Kirkuk, is contrary to Iraqi interests. Thus, any policy to eliminate this asymmetry will benefit the Iraqi public. Increased inventory capacity as well as less reliance on oil revenue for public spending will help Iraqi authorities get more flexibility for their oil supplies and thus decrease the adverse effects of the asymmetry. Moreover, since the statistical evidence for the asymmetry in the Asian markets is stronger, targeting European markets may benefit the Iraqi economy.

In a demand-driven oil market, Iraq will have difficulties in optimizing its oil revenues as the market always remains in contango, and OSPs tend to be under pressure. In market competition against Saudi Arabia and the UAE, Iraqi authorities will have to downgrade OSP strategy while having a higher fiscal burden and demand fiscal break prices. On the other hand, most of the major oil fields in the Basrah region are operated under technical service contracts. The Iraqi government pays a fixed fee per barrel of oil produced without a balancing mechanism against global oil prices. In contango conditions, this will likely add more pressure on the fiscal side with shrinking oil revenues.

Iraq's OSP strategy seems aligned and reactive against its competitors due to a lack of fiscal and operational flexibility. SOMO needs to enhance its export and logistics capabilities to compete against its competitors. This way, they can optimize the OSP strategy to reflect its fiscal needs rather than fighting for its market share. Iraq's latest attempt to supply Basrah Medium grade is logical since it would provide a more competitive grade that helps them advance OSP strategy.

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