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DISCUSSION PAPER SERIES

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ABSTRACT

Investigating the Asymmetric Impact of Oil Prices on GCC Stock Markets*

This paper investigates the presence of asymmetric relationship between oil price movements and Gulf Cooperation Council (GCC) stock markets. We propose the implementation of nonlinear vector smooth transition regression (VSTR) models which offer a greater flexibility when modelling the possible asymmetric reaction in equities. Contrary to conventional wisdom, our empirical results reveal that GCC stock markets do not have similar sensitivities to oil price changes. We document that oil price changes have asymmetric effects on stock returns in some GCC countries, but not for others. More specifically, we find four out of six GCC stock markets that are more sensitive to large oil deviations than to small ones. Our results highlight the importance of economic stabilization and reform policies that can potentially reduce the sensitivity of stock returns to oil price changes, especially with regard to the existence of asymmetric behavior.

JEL Classification: G12, F3, Q43

Keywords: GCC stock markets, oil prices, smooth transition regression models

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1. Introduction

A thorough understanding of stock markets' dependence on oil price changes is consistently valuable for policymakers in countries that are heavily reliant on hydrocarbon revenues, such as the Gulf countries. A wave of structural reforms that diversify the economic base and raise nonoil sources are of particular importance to temper and smooth the impacts of oil shocks on stock returns over time. The Gulf Cooperation Council (GCC) countries had combined proven reserves of 497 billion barrels of crude oil as of December 2018. This represents about 34 percent of the total proven oil reserves in the world.[1] Petrodollar accumulation, with the oil price nearly tripling from $50 in early 2007 to $147 before the global financial crisis (GFC), began to take hold in late 2008. Although GCC economies share similar economic and political characteristics, they still differ to some extent in their levels of dependency on oil and in their efforts in economic reforms. Bahrain, for example, is less reliant on oil than Saudi Arabia and Kuwait. Oil rents (difference between the value of crude oil production and total costs of production) range from 2.3 percent of GDP for Bahrain to 36.3 percent of GDP for Kuwait in 2018 (see Figure 1). This situation, along with the global investment of their sovereign wealth funds and a greater financial liberalization, has given GCC countries greater exposure to international markets. A better understanding of oil-stock linkage in the GCC region of is of great relevance and would have important implications for both investors and policymakers.

Our paper aims to shed further light on the presence of asymmetric relationship between oil price changes and GCC stock markets. The crude oil market has experienced huge swings and boom-bust cycles over the last two decades, such as the spectacular increase in early 2008, and the great plunge of 2014-2015. In conjunction with the dramatic change in the financial environment since the eruption of the US subprime crisis, the presence of structural breaks and regime shifts has revived the belief in an asymmetric, nonlinear relationship between oil prices and stock markets. Over the past decade, there has been an increasing interest in examining the potential nonlinear and asymmetric linkages between oil price movements and stock markets. Although most early studies have relied on linear econometric modelling, it is now well

[1] Data for crude oil proven reserves are from the US Energy Information Administration (EIA).

established that overlooking potential nonlinearity can lead to misleading results (see e.g. Balcilar et al., 2015; Ciner, 2001; Sadorsky, 1999). A great deal of the recent empirical literature has focused on the asymmetry arising from the direction of oil price change, in the sense that stock prices respond asymmetrically to oil price decreases and increases (see e.g. Fenech and Vosgha, 2019; Park and Ratti, 2008; Reboredo and Ugolini, 2016; Ramos and Veiga, 2013; Wang et al., 2013, among others). For instance, negative oil price deviations are found to have larger impacts on stock returns than their positive counterparts in oil-exporting countries (see e.g. Sim and Zhou, 2015, and Mohanty et al., 2011).[2] The contribution of our study with respect to the existing literature is threefold: first, we propose the implementation of the class of nonlinear smooth transition regression (STR) models where the possible existence of regime shift can be identified with respect to an estimated threshold (see Granger and Teräsvirta; 1993; Teräsvirta, 1994). The use of an STR framework enables us to explore the two possible sources of asymmetry in stock price reactions, namely, the direction and magnitude of oil price change. In spite of its policy relevance, little is said about whether oil price shocks are asymmetric in magnitude; namely, if the effects of large oil price changes on stock prices prove to be different from the effects of smaller shocks. Furthermore, ad hoc methods have often been implemented to measure the asymmetric reactions of stock market returns to oil price changes. For instance, in a sample of GCC countries, Mohanty et al. (2011) introduce a dummy variable to capture the asymmetry with respect to oil price decreases and increases. While declines in oil prices negatively impact all GCC stock markets, Mohanty et al. (2011) reveal that oil price increases have mixed effects on stock returns. Since linear and ad hoc approaches would potentially lead to counterintuitive, mixed results, we propose the use of regime-switching models, where the nonlinear dynamic is generated endogenously from the data. To capture the asymmetry arising from the direction of oil price shock, we use a logistic smooth transition specification, which is appropriate for separating oil prices into positive and negative changes. However, when capturing asymmetric behavior with respect to

[2] It is worth noting that the focus of the earlier literature is on the relationships between oil prices and macroeconomic variables. They provide evidence proving that oil price increases exert larger impacts on economic activity than oil price decreases. (see e.g. Hamilton, 1996; Mork, 1989).

the size of oil price's movement, an exponential form is applied for distinguishing between large and small oil price changes.

Second, recent empirical studies have emphasized the potential endogenous character of oil-price changes when estimating their impact on equity returns (see e.g. Abhyankar et al., 2013; Barsky and Kilian, 2002; Degiannakis et al., 2018, Park and Ratti, 2008; Sadorsky, 1999). Our paper considers a vector STR (VSTR) framework that takes explicitly account of the endogeneity issue inherent in the single-equation-based approach. The VSTR model is a straightforward extension of the univariate STR model to a multivariate setting (see e.g. Hubrich and Teräsvirta 2013; Teräsvirta and Yang, 2014). The modeling strategy is very appealing, as it allows us to remedy both endogeneity and regime transition issues. To the best of our knowledge, the present paper is the only study that implements a nonlinear VSTR methodology while investigating the oil-stock nexus.

Finally, it is well-known that the economies of GCC are very sensitive to regional political events that may have an influence on the transitional path of stock market responses to oil market developments. Given the rising political tensions in the GCC region, especially after the outbreak of Arab uprisings in late 2010, it would be useful to control for geopolitical risk in our empirical estimations. In our VSTR system, we propose to introduce a new indicator of geopolitical risk (GPR), as proposed by Caldara and Iacoviello (2018). This index is constructed to measure risks associated with wars, tensions between states, and terrorist acts that affect the normal course of international relations. Our study is conducted for a sample of six GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE), using monthly data over January 2005–December 2019.

The remainder of this paper proceeds as follows: Section 2 discusses the literature on the asymmetric impact of oil on equity markets, also giving some features of the GCC group. Section 3 presents the data and their statistical properties. Section 4 describes the empirical methodology and specification. Section 5 is devoted to the presentation and the discussion of our empirical results. Section 6 discusses some policy implications for the GCC group. Finally, Section 7 offers some concluding remarks.

2. Asymmetric Oil-Stock Nexus and GCC Markets Features

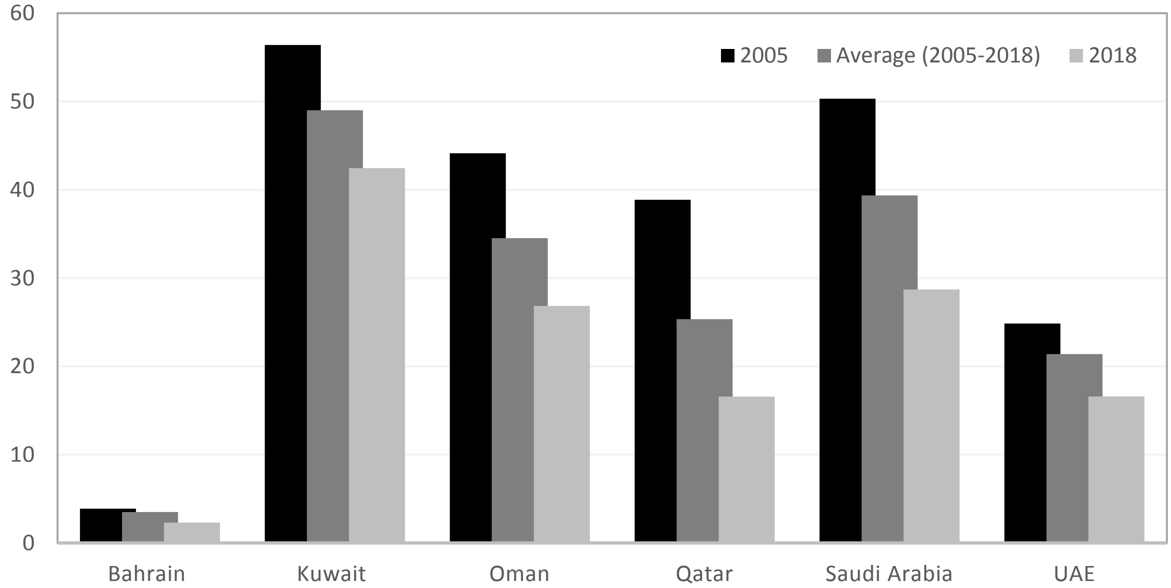
Numerous studies in recent years have examined the interaction between oil and stock markets with an increasing focus on developing and emerging market countries, including Gulf Cooperation Council (GCC) countries. A crucial aspect in this relationship is whether equity returns are reacting nonlinearly to oil-market shocks. The wild fluctuations in oil prices over the past decade, such as the spectacular boom of 2008 and bust of 2015, has motivated several empirical analyses that emphasize characteristics such as nonlinearities and asymmetries. For the case of GCC countries, structural shift has been documented in the aftermath of the 2008 global crisis, as the sensitivity of Gulf stock markets to energy prices is becoming more apparent (see e. g. Akoum et al., 2012; Arouri et al., 2011; Awartani and Maghyereh, 2013). The most common type of nonlinearity that has been investigated in the literature is whether stock returns respond asymmetrically to crude oil price decreases and increases.[3] This kind of asymmetric relationship was typically captured by introducing positive and negative oil price changes separately into the model or by constructing various variables of oil prices variation, such as the net oil price increases of Hamilton (2003).[4]

While the asymmetric effect of oil prices on economic activity is well-documented, the existing empirical literature is not conclusive for its relevance for the oil-stock relationship. In a sample of major oil-importing and exporting countries, Wang et al. (2013) examined the potential nonlinear linkage between oil prices and equity returns.[5] The authors employed two kind of linearity tests and revealed that for most countries in their study no significant nonlinear dependance is found.[6] For a panel of 18 oil-importing and oil-exporting countries, Ramos and Veiga (2013) supported the presence of asymmetric effects only in oil-importing countries. Nevertheless, using a time-varying copula approach, Fenech and Vosgha (2019) have supported the presence of asymmetric behavior across all the GCC countries where stock returns are more responsive to decreases in oil price drops than to increases. In the same vein,

[3] As is well-known, the sign of the relationship between oil prices and stock indices depends on whether a country is a net oil-importing or oil-exporting economy (see e.g. Basher et al., 2018; Ramos and Veiga, 2013; Wang et al., 2013).
[4] To capture the impact of oil prices on the economy, Hamilton (2003) has defined a measure of net oil price increase that represents new highs relative to the previous experience, or reversals of recent declines.
[5] In another strand of literature, Julio et al. (2019) have found that oil shocks have asymmetric and nonlinear causal effects on the sovereign credit risk of oil-exporting and oil-importing countries.
[6] Wang et al. (2013) performed tests for asymmetry as suggested by Hamilton (1996, 2003), and a modified version of Hiemstra and Jones (1994)'s nonlinear Granger causality as developed by Diks and Panchenko (2006).

using nonlinear autoregressive distributed lag (NARDL) models, Siddiqui et al. (2019) found that during the oil price collapse of 2014–2016, negative oil price changes had relatively larger effects than positive oil price changes on stock indices in the oil-exporting countries, such as the GCC group.

Figure 1. Oil rents (% of GDP) in the GCC countries



Source: Data are obtained from the EIA and the World Bank. Note: Oil rents are the difference between the value of crude oil production at world prices and total costs of production.

In another strand of literature, a Markov-switching framework has been applied to analyze the nonlinear dynamic linkage between oil price shocks and financial markets. For instance, in a sample of oil-exporting and oil-importing countries, Zhu et al. (2017) have proposed to gauge the effect of oil shocks on equities using a Markov-regime switching model. According to the authors' results, a very weak impact is found in the low volatility regime, while a significant reaction is recorded in the high volatility regime. In our study paper, we propose the implementation of a different class of regime-switching models, where two types of asymmetry can be modeled, i.e. with respect to both the direction and magnitude of oil price shock. The introduction of a smooth-transition mechanism would offer an extra flexibility in capturing the potential asymmetric behavior.[7] Moreover, unlike the nonlinear threshold models, in which a very small number of regimes are identified, the use of the family of STR models allows for the presence of a continuum of intermediate states between the extreme

[7] As stated by Tong (1990) in his survey on nonlinear time series models, the family of STR models can be viewed as a form of regime-switching model in an abroad sense, as it allows for a gradual transition across the identified states.

régimes. The STR models are considered as generalization of threshold models where a steep transition is nested as a special case (see e.g. Teräsvirta, 1994).[8]

The economies of GCC have some unique features that would make opportunities for portfolio diversification possible for both domestic and foreign investors. Unlike net oil-importing countries, a positive relationship is expected between oil prices and the GCC equity markets, as reported by many recent studies.[9] Moreover, stock markets in the Gulf countries are different from other developed or emerging markets as they are more segmented, and less integrated with international markets. Although they are notably sensitive to geopolitical tensions in the region, the increased degree of financial liberalization and the ongoing structural reforms would play an important role in investment decisions. In more recent years, GCC countries have loosened restrictions for foreign investors and implemented a wide range of legal, regulatory, and supervisory changes to strengthen market transparency. This financial liberalization has contributed to the further development of formal stock markets in the region. The total market capitalization of GCC stock markets was $1,040 billion in 2018, an almost one-and-a-half times greater than $680 billion of 2005 (see Figure 2). Saudi Arabia's stock market, the largest in the region, accounts for 46 percent of stock market capitalization in the GCC. The smallest stock market in the region is Bahrain's. In terms of total listed companies, Figure 2 shows the rapid increase of listed companies from 2005 to 2018.

A better understanding of oil-stock linkage in the GCC region of is of great relevance and would have important implications for both investors and policymakers. As the region has witnessed an increased political instability in the aftermath of the Arab uprising of late 2010, along with the extreme variability in both oil and financial markets, this justifies the usage of regime-switching models to capture the existence of potential asymmetry and structural shifts. While this is not the only way of modeling nonlinearities, the family of STR models are very appealing for describing series having asymmetric dynamic behavior and structural instability (see e.g. Skalin and Teräsvirta, 1999).

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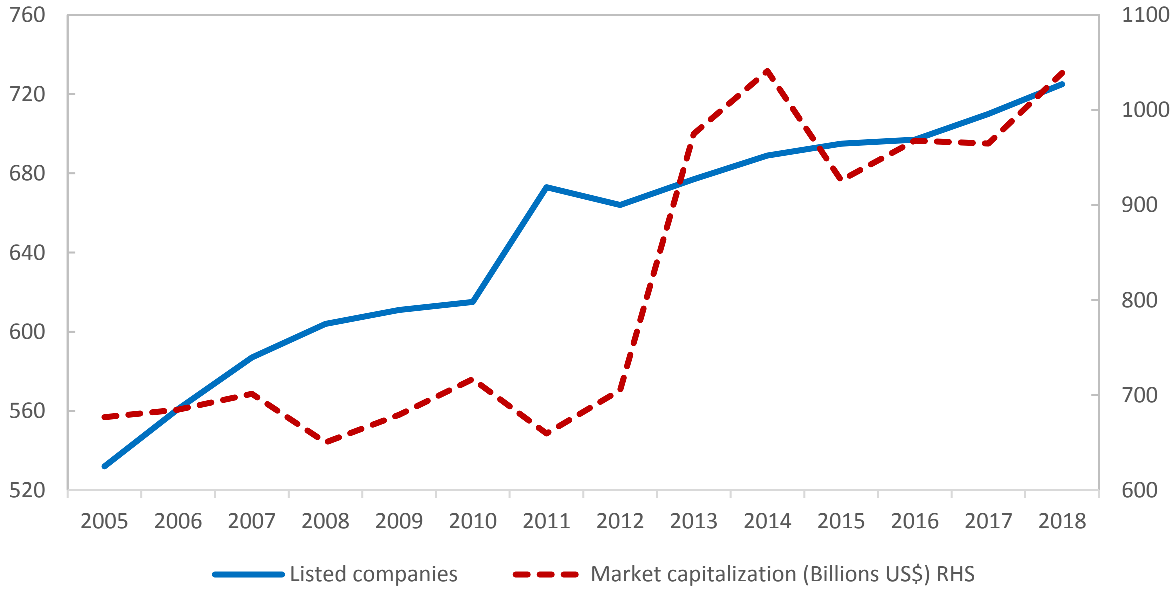
[8] When testing forecasting performance for real exchange rates, Sarantis (1999) argued that STR models provide better results than Markov-switching models.

[9] Park and Ratti (2008) revealed that spikes in oil prices impact negatively equity returns in the US and 12 European countries, while in oil-exporting countries, such as Norway, stock market reaction is found to be positive. Besides, based on copula approach, Mokni and Youssef (2019) documented a significant positive relationship between oil and GCC stock markets, with Saudi equities having the strongest link and persistence of dependence on the crude market.

Figure 2. GCC Stock Market: Listed Companies and Market Capitalization



Source: Arab Monetary Fund.

3. Data and Their Properties

In order to examine the asymmetrical effects of oil price fluctuations on stock returns, our study focuses on the case of the six GCC countries: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE. We select monthly data spanning the period of January 2005–December 2019.[10] As for oil data, we use the monthly Brent spot prices to analyze the international crude oil market. Oil prices are denominated in US dollars and available from the US Energy Information Administration (EIA). We compute oil returns using the first logarithmic difference of oil prices, or_t.[11] The stock market data are monthly average national stock price indices for the six GCC countries, expressed in US dollars, gathered from the Morgan Stanley Capital International (MSCI) database. We use monthly returns, defined as the first logarithmic differences of monthly stock price indices (sr_t).

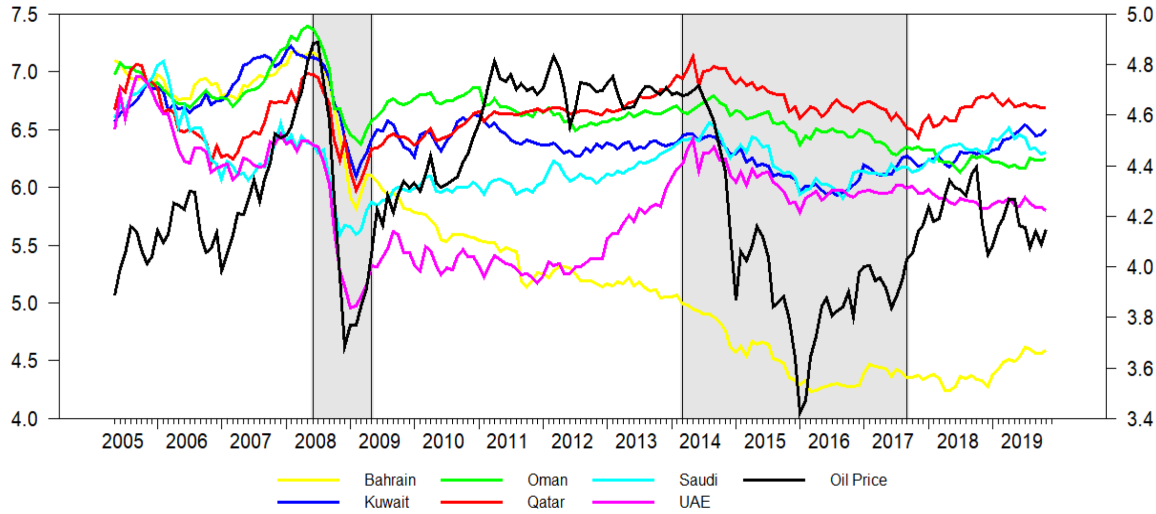
Moreover, some control variables should be considered in our empirical specification. We include the monthly MSCI World Index returns, wr_t, and the US three-month treasury bill

[10] Several empirical studies consider high-frequency data when investigating oil-stock-prices nexus. As a matter of fact, daily or weekly time series are subject to conditional heteroskedasticity issues which is not appropriate for the implementation of smooth-transition-type models (see Teräsvirta, 1994 for a detailed discussion). Our study proposes the estimation of VSTR models using monthly data to avoid the possible of presence of ARCH effects. For papers that also use monthly data see e.g. Apergis and Miller (2009); Diaz et al. (2016); Miller and Ratti (2009); Park and Ratti (2008) and Sadorsky, 1999), among others.

[11] To check for robustness, we employ other crude oil benchmarks, i.e., West Texas Intermediate (WTI) and OPEC spot prices. These oil prices did not significantly alter the results of our benchmark specifications.

(T-bill) interest rate, i_t^{us}. The MSCI World Index and the US three-month T-bill interest rate are among the global factors that strongly influence GCC stock markets. Since GCC global investors consider both local and world markets, GCC stock markets can be affected by World Index fluctuations. As Gulf countries are tightly linked to US monetary policy, due to the links between their national currencies and the US dollar, we include the US interest rate as a proxy for the GCC interest rate. We obtain the above financial information from the MSCI database.

Figure 3. GCC Stock Market Indices and Brent Oil Prices



Note: Data are monthly log levels of GCC stocks and Brent oil prices. Data are obtained from the EIA and MSCI database.

Furthermore, given the episodes of rising political tensions in the GCC region, it would also be useful to control for geopolitical risk in our empirical estimations. As shown in Figure 3, Qatari equities have dramatically declined during the recent diplomatic crisis of 2017. The events and rising geopolitical tensions could serve as a test, not just for Qatar but for all the GCC countries, for the marginal contribution of a non-oil related event on an equity market sell-off in the Gulf region. In our empirical specification, we propose to consider an indicator of geopolitical risk (GPR) as proposed by Caldara and Iacoviello (2018). This index is constructed to measure risks associated with wars, tensions between states, and terrorist acts that affect the normal course of international relations.[12] Caldara and Iacoviello (2018) have

[12] Using the economic policy uncertainty (EPU) index of Baker et al. (2016), many recent studies have considered the risks associated with policy changes and how they can influence the oil-stock relationship (see e.g. Arouri et al., 2014; Basher et al., 2018; Kang et al., 2017). While EPU index is mainly based on newspaper coverage of policy-related economic uncertainty, the GPR index of Caldara and Iacoviello (2018) considers the occurrence of words related to geopolitical tensions in 11 leading international newspapers. For example, the GPR index would

provided monthly country-specific GPR indexes constructed for 18 emerging economies. Among the GCC economies, the GPR has been calculated only for Saudi Arabia. Being the largest oil exporter in the world and the leader among GCC stock markets, it is expected that the rising political tensions in Saudi Arabia would affect the other GCC members.[13] Therefore, a monthly GPR index for Saudi Arabia, gpr_t^{ksa}, will be considered in our empirical data.[14]

Plots of the GCC stock market indices and Brent oil price are reported in Figure 3. After nearly five years of stability from 2010 to mid-2014, the Brent crude oil price has fallen to its lowest level in 10 years. The time series plots of our six stock price indices reveal that the oil-boom-bust cycle of 2007–2009—compounded by the spillover of the subprime crisis—has strongly impacted the GCC stock market. Similarly, the spectacular oil collapse of 2014-2015 seems to entail a significant decline in the equity prices. The log levels of GCC stocks and Brent oil prices plotted in Figure 3 show some common trending behaviors, which may be indicative of some interdependence between all markets. The stock prices in the Gulf region are increasing (declining) as oil prices are rising (falling).

Table 1 presents some summary statistics on stock market indices and oil returns over 2005–2019. It is worth highlighting that monthly average returns on GCC's national stock markets are negative throughout our sample, which may indicate the effect of the oil price decline in late 2008, as well as that of the dramatic collapse of 2014–2015. We document a slight positive average stock return only for Qatar (0.01 percent). However, the global equity market proxied by the MSCI World Index is performing well over this period, having an average return more than 0.40 percent. This would indicate the heavy dependence of Gulf region to oil market compared to the rest of the world.[15] Besides, Qatari, Saudi and Emirati markets are shown to have recorded the highest variabilities as measured by the standard deviation. Table 1 also reveals a positive average return of 0.11 percent for the Brent oil prices, as well as a higher volatility rate, as a result of the last two decades' boom-bust in the crude market.

have a higher value around the Gulf War, during the 2003 Iraq invasion or during the recent Yemen conflict. As Gulf countries are more sensitive to regional political tensions in the Middle East, the GPR index is found to be more relevant when estimating our VSTR models.

[13] See e.g. Alqahtani et al. (2020), Benlagha (2020), and Buigut and Kapar (2020), for a recent literature on the 2017 Gulf diplomatic crisis.

[14] The monthly GPR index for Saudi Arabia is available at http://www.policyuncertainty.com/gpr.

[15] Using Dynamic Conditional Correlation-GARCH model and the spillover index of Diebold and Yilmaz (2009, 2012), Ziadat, et al. (2020) found that the GCC group exhibits a lower degree of integration with major international stock markets.

Table 1. Descriptive Statistics for Stock and Crude Market Returns

	Mean	Min.	Max.	Std. Dev.
Stock prices				
Bahrain	-1.44	-33.33	16.09	6.72
Kuwait	-0.03	-21.12	19.08	6.08
Oman	-0.42	-35.47	12.60	5.59
Qatar	0.01	-30.77	20.96	7.83
Saudi Arabia	-0.17	-25.39	17.96	7.76
UAE	-0.40	-40.59	30.93	9.52
Brent oil prices	0.11	-31.10	19.60	8.91
MSCI World Index	0.41	-21.13	10.35	4.35
US T-bill	1.29	0.01	5.16	1.66
GPR index	103.16	44.69	196.28	26.87

Note: Data on stock market indices and oil prices are monthly returns using first log differences of monthly series. All variables are in percentage except for GPR index.

Finally, we examine the time series properties of our key variables by checking stationarity. The presence of unit roots is checked for variables in the levels (logarithmic price series) and first differences (return series) of oil and equities. First, we perform the modified Dickey–Fuller proposed by Elliott et al. (1996), the so-called DF-GLS test. The procedure consists of transforming the series via a generalized least squares (GLS) regression before conducting the test. The DF-GLS test has proved better statistical power compared to former versions of Dickey-Fuller tests. Moreover, given that our study period covers episodes of high fluctuations in oil and stock markets, structural changes would occur in the oil and stock return series. Thus, a DF-GLS unit root test might not be powerful in the presence of a structural break in the considered series.[16] For the sake of robustness, we implement Lumsdaine and Papell (1997, LP henceforth) unit root test which allows for possible breaks in series.[17] Furthermore, as we expect the presence of a nonlinear dynamic in our key variables, Kapetanios, et al. (2003, KSS hereafter) test (KSS hereafter) is also applied, where the null of nonstationarity is tested against nonlinear stationary exponential smooth transition model.[18] Logarithmic price series are tested in the presence of both an intercept and a trend. For returns series, unit root tests are conducted only with an intercept due to the absence of trending behavior in first difference variables.

[16] In their study on crude oil market efficiency, Arshad et al. (2020) stressed the lower power and statistical inefficiencies of the traditional unit root tests as they might not detect trends and structural breaks in oil time series.

[17] LP test is the extension of Zivot and Andrews (1992) unit root test by allowing for two structural breaks under the alternative hypothesis. As stated by Koop and Potter (2000), structural breaks could be the origin of nonlinear dynamic behavior in economic time series

[18] See e.g. Smyth and Narayan (2015), for a detailed discussion on unit root tests and their implementation in the energy economics literature.

Main results from unit root tests are reported in Table 2 for variables in levels and first differences. Our findings show that, when using DF-GLS unit root tests, the null hypothesis of a unit root cannot be rejected for all variables across levels, except for the US three-month treasury bill and the GPR index. In fact, there was a dramatic fall in US interest rates following the recent financial crisis, which may indicate the presence of structural changes in the data. Hence, when using LP and KSS unit root tests, the US three-month treasury bill series are found to be nonstationary in level, while the stationarity of the GPR index is still robust. For variables in first log differences, all unit root tests suggest that we should reject the null hypothesis of nonstationarity.[19]

Table 2. Unit Root Tests

	DF-GLS test		LP test		KSS test	
	level	1st diff.	level	1st diff.	level	1st diff.
Stock prices						
Bahrain	-1.294	-3.718***	-4.261	-10.243***	-1.545	-3.686***
Kuwait	-1.990	-2.639**	-4.892	-7.651***	-1.454	3.621***
Oman	-1.497	-2.449**	-5.615	-6.622***	-2.035	-4.659***
Qatar	-1.157	-2.976**	-4.607	-7.264***	-2.046	-3.995***
Saudi Arabia	-2.530	-3.742***	-3.637	-12.692***	-2.490	-4.450***
UAE	-1.433	-3.831***	-5.522	-7.758***	-1.647	-3.606***
Brent oil prices	-1.552	-4.542***	-5.576	-10.714***	-1.437	-4.075***
MSCI World Index	-2.253	- 2.905***	-4.244	-12.649***	-1.718	-3.923***
US T-bill	-2.966**	5.620***	-5.192	-9.342***	-2.372	-4.471 ***
GPR index	- 3.151**	-5.058***	-6.342**	-9.880***	-3.073**	-4.543***

Note: DF-GLS, LP (Lumsdaine and Papell, 1997), and KSS (Kapetanios, et al., 2003) tests are performed using log prices and return series. *, **, and *** indicate rejection of the null hypothesis at the 10%, 5%, and 1% levels, respectively. Akaike Information Criterion (AIC) is used here for optimal lag length selection with maximum number of lags = 8.

4. Empirical Methodology

In this paper, we propose the implementation of the family of regime-switching models, namely nonlinear smooth transition models, where it is possible to model two sources of asymmetry. On the one hand, we analyze the asymmetric effects of positive and negative oil price variations on stock returns. On the other hand, we check whether large shocks have more pronounced effects than small ones. Furthermore, considering price oil movements as

[19] We have conducted Enders and Siklos' (2001) threshold cointegration test where the possible presence of long-run equilibrium relationship is tested by permitting for asymmetric adjustment in the error correction mechanism. As reported in Table A1 in Appendix, the null assumption of no cointegration cannot be rejected for all GCC countries, except for Saudi Arabia. While hardly contestable on theoretical grounds, it is worth stressing that several empirical studies were not able to restore the long-run equilibrium relationship (see e.g. Apergis and Miller, 2009; Kang et al., 2017, Park and Ratti, 2008, among others). Note that the first differences variables for price series are considered here when estimating the impacts of oil prices on stock prices for all GCC countries.

exogenous variables with respect to other factors that determine the course of the economy is not realistic (Barsky and Kilian, 2002). Empirical studies on GCC countries have suggested that changes the Saudi economy, as the world's number one oil exporter, would significantly cause changes in OPEC oil prices (see e.g. Arouri and Rault, 2010; Hammoudeh and Aleisa, 2004; Zarour, 2006).[20] Then, our empirical strategy suggests the use of a vector STR (VSTR) framework which stands as a straightforward extension of the single-equation STR model to a multivariate setting. Taking into account the underlying dynamic interrelations between oil prices and macro-finance variables that also affect stock prices would ensure further accuracy in estimates. We consider a single-transition (two extreme regimes) version of the VSTR model specified as:[21]

$$i_t^{us} = \beta_{1,0} + \sum_{i=1}^{N} \beta_{i,1,1} i_{t-i}^{us} + \sum_{i=1}^{N} \beta_{i,1,2} wr_{t-i} + \sum_{i=1}^{N} \beta_{i,1,3} or_{t-i} + \sum_{i=1}^{N} \beta_{i,1,4} sr_{t-i} + \sum_{i=1}^{N} \beta_{i,1,5} gpr_t^{ksa}$$
$$+ \left(\phi_{1,0} + \sum_{i=1}^{N} \phi_{i,1,1} i_{t-i}^{us} + \sum_{i=1}^{N} \phi_{i,1,2} wr_{t-i} + \sum_{i=1}^{N} \phi_{i,1,3} or_{t-i} + \sum_{i=1}^{N} \phi_{i,1,4} sr_{t-i} \right) G_1(s_{1,t}; \gamma_1, c_1) + \varepsilon_{1,t}, \quad (1)$$

$$wr_t = \beta_{2,0} + \sum_{i=1}^{N} \beta_{i,2,1} i_{t-i}^{us} + \sum_{i=1}^{N} \beta_{i,2,2} wr_{t-i} + \sum_{i=1}^{N} \beta_{i,2,3} or_{t-i} + \sum_{i=1}^{N} \beta_{i,2,4} sr_{t-i} + \sum_{i=1}^{N} \beta_{i,2,5} gpr_t^{ksa}$$
$$+ \left(\phi_{2,0} + \sum_{i=1}^{N} \phi_{i,2,1} i_{t-i}^{us} + \sum_{i=1}^{N} \phi_{i,2,2} wr_{t-i} + \sum_{i=1}^{N} \phi_{i,2,3} or_{t-i} + \sum_{i=1}^{N} \phi_{i,2,4} sr_{t-i} \right) G_2(s_{2,t}; \gamma_2, c_2) + \varepsilon_{2,t}, \quad (2)$$

$$or_t = \beta_{3,0} + \sum_{i=1}^{N} \beta_{i,3,1} i_{t-i}^{us} + \sum_{i=1}^{N} \beta_{i,3,2} wr_{t-i} + \sum_{i=1}^{N} \beta_{i,3,3} or_{t-i} + \sum_{i=1}^{N} \beta_{i,3,4} sr_{t-i} + \sum_{i=1}^{N} \beta_{i,3,5} gpr_t^{ksa}$$
$$+ \left(\phi_{3,0} + \sum_{i=1}^{N} \phi_{i,3,1} i_{t-i}^{us} + \sum_{i=1}^{N} \phi_{i,3,2} wr_{t-i} + \sum_{i=1}^{N} \phi_{i,3,3} or_{t-i} + \sum_{i=1}^{N} \phi_{i,3,4} sr_{t-i} \right) G_3(s_{3,t}; \gamma_3, c_3) + \varepsilon_{3,t}, \quad (3)$$

$$sr_t = \beta_{4,0} + \sum_{i=1}^{N} \beta_{i,4,1} i_{t-i}^{us} + \sum_{i=1}^{N} \beta_{i,4,2} wr_{t-i} + \sum_{i=1}^{N} \beta_{i,4,3} or_{t-i} + \sum_{i=1}^{N} \beta_{i,4,4} sr_{t-i} + \sum_{i=1}^{N} \beta_{i,4,5} gpr_t^{ksa}$$
$$+ \left(\phi_{4,0} + \sum_{i=1}^{N} \phi_{i,4,1} i_{t-i}^{us} + \sum_{i=1}^{N} \phi_{i,4,2} wr_{t-i} + \sum_{i=1}^{N} \phi_{i,4,3} or_{t-i} + \sum_{i=1}^{N} \phi_{i,4,4} sr_{t-i} \right) G_4(s_{4,t}; \gamma_4, c_4) + \varepsilon_{4,t}, \quad (4)$$

where $G_j(s_{j,t}; \gamma_j, c_j)$ the transition functions that controls the nonlinear dynamic of the model, with $s_{j,t}$ as the transition variable, γ_j the slope parameter that measures the speed of transition across regimes, c_j is the threshold value in each transition function, with $j = 1,2,3,4$, and $\varepsilon_t = [\varepsilon_{1,t}, \varepsilon_{2,t}, \varepsilon_{3,t}, \varepsilon_{4,t}]$ is the disturbance vector. Given that geopolitical events are assumed to be strictly exogenous to macro-finance variables—but rather related to events that affect the normal course of international relations— the GPR index is included in the system as an

[20] EIA reports that net oil export revenues from Saudi Arabia amounted $133 billion in 2016. The country possesses around 16 percent of the world's proven petroleum reserves, and with roughly 12 million barrels per day, it possesses the world's largest crude oil production capacity.
[21] For more general representations of multitransitional VSTR models, see Teräsvirta and Yang (2014).

exogenous variable.[22] In the VSTR representation, strongly exogenous variables are permitted as stated in Hubrich and Teräsvirta (2013). Following Camacho 2004, we allow for the transition functions to be different across our four-equation in the VSTR system for more flexibility. Our main focus is equation (4), as we intend to investigate the asymmetric reaction of GCC stock market returns to oil price changes. Accordingly, it is possible to compute the long-run impact of oil price change, which is given by the following time-varying coefficients: $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\, G_4\left(s_{4,t}; \gamma_4, c_4\right)\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$, where oil price change is used as a transition variable ($s_{4,t} = or_{t-i}$).

The STR literature has provided different forms for the transition function. Among those most used are logistic and exponential specifications. The representation of the logistic function is given by $G_4(or_{t-i}; \gamma_4, c_4) = [1 + exp\{-\gamma_4(or_{t-i} - c_4)\}]^{-1}$, while the exponential specification is expressed as $G_4(or_{t-i}; \gamma_4, c_4) = 1 - exp\{-\gamma_4(or_{t-i} - c_4)^2\}$. Using the logistic transition function, our multivariate system corresponds to a logistic VSTR (LVSTR) model. In this case, the effects of oil prices on stock markets takes different values depending on whether the transition variable or_{t-j} is below or above threshold value. The use of LVSTR specification would be appropriate in accounting for asymmetry with respect to the direction of oil price change, (the asymmetry between negative or positive oil shocks), especially when the threshold value is close to zero, $c_4 \simeq 0$. If $(or_{t-i} - c_4) \to -\infty$ (for a negative oil shock), the impact on stock price corresponds to $\sum_{i=1}^{N} \beta_{i,4,3} / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. If $(or_{t-i} - c_4) \to +\infty$ (for a positive oil shock), oil effect becomes $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. For the choice of the exponential from as a transition function, the empirical framework corresponds to the so-called exponential VSTR (EVSTR) model. The implied nonlinear dynamic will be different from that in the LVSTR specification, in the sense that oil price change's impact depends on whether or_{t-i} is close to or far away from the threshold c_4, regardless of whether the difference $(or_{t-i} - c_4)$ is positive or negative. The exponential specification would be more useful in capturing asymmetry with respect to the magnitude of oil price change, that is, whether an oil shock is small or large. Therefore, if $(or_{t-i} - c_4) \to \pm\infty$ (for a large oil shock), the effect on the stock market will be equal to $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. If $or_{t-i} = c_4$ (for a small oil shock), oil price's impact becomes $\sum_{i=1}^{N} \beta_{i,4,3} / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. For the selection of the optimal lag length entering the VSTR model, different information criteria could be used, such as Akaike

[22]As stated by Barsky and Kilian (2004, exogenous political events the Middle East are key factors in driving oil prices movements.

Information Criterion (AIC), Bayesian Information Criterion (BIC), among others. As shown in Table A2 in Appendix, different selection criteria would lead to different results in terms of optimal lag length. A standard approach in the STR literature is to conduct a general-to-specific procedure by removing sequentially the variables corresponding to less significant parameter estimates (see, e.g., Camacho, 2004; van Dijk et al., 2002).

Next, in line with Teräsvirta and Yang (2014, we implement the modelling strategy for STR models within a multivariate context. We first use our VSTR models to test for nonlinearity. This will enable us to select the appropriate lagged oil price change as a threshold variable, and the appropriate specification for the transition function, namely, the logistic or exponential form. The linearity tests are conducted for each lag of the transition variable, or_{t-i}, with $i = 1, \cdots, 8$. Next, the parameters of our single-transition VSTR system are estimated using the nonlinear least squares (NLS) estimation procedure. As stated by Teräsvirta and Yang (2014). The NLS technique provides estimators that are consistent and asymptotically normal.[23] Finally, a diagnostic check is performed to test the quality of our estimated model using some misspecification tests. Of the most frequently used tests in the VSTR literature, we implement the Lagrange Multiplier (LM) tests of no remaining nonlinearity and parameter constancy.[24]

5. Empirical Results

5.1. Results from linearity tests

We begin by testing the null hypothesis of linearity (H_0) against the STR alternative.[25] As recommended by Teräsvirta (1994), we select the lagged transition variable having the lowest p-value in terms of rejection of linearity (see $\min(H_0)$ in Table 3). If the null assumption of linearity is rejected, a sequence of nested null hypotheses (H_{04}, H_{03}, H_{02}) are employed to determine the relevant functional form (logistic or exponential).[26] However, if none of the p-values is sufficiently small, the alternative of nonlinear STR model is rejected. As shown in Table 3, there is a strong evidence for the presence of nonlinearity in our six GCC countries, except for the UAE. Accordingly, there is a potential asymmetry in the transmission of oil price

[23] Given that transition functions are supposed to be different in our setting, the estimation procedure is done equation by equation in the same way as for a single-equation STR models (see e.g. Teräsvirta and Yang, 2014).
[24] Diagnostic check tests performed here consist of Eitrheim and Teräsvirta's (1996) tests extended to a multivariate setting (see e.g. Camacho, 2004).
[25] As the transition function is supposed to be different our the VSTR framework, tests of linearity are conducted for each equation separately as in the single-equation STR. However, if the transition function is assumed to be the same for the whole VSTR, a system-wise test is used as in Teräsvirta and Yang (2014).
[26] See Teräsvirta (1994) for further details on the procedure of test of linearity.

change to equity returns. It is important to note that no remaining nonlinearity tests are applied after the estimation in order to choose the best transition variable. The transition variables to be selected should provide the highest rejection of both the null of linearity (H_0) against the STR model and of the lack of additive nonlinearity.[27] Once linearity has been rejected, the sequential tests for choosing the adequate transition function is performed. The last column of Table 3 indicates the best specifications, in terms of rejection of linearity, and of no additive nonlinearity. The logistic form is found to be the best specification for Bahrain and Kuwait. The exponential specification seems to be more relevant for Oman, Qatar, and Saudi Arabia.

As discussed in the STR literature, the decision rule which is based on the sequential nested null assumptions is becoming less important due to advances in computing capabilities. Therefore, it would be more convenient to estimate both LVSTR and EVSTR specifications, and then use diagnostic tests for the choice of the best form. Also, the underlying economic theory can give clues as to which functional from to be taken for the transition. Our paper proposes to examine the two possible sources of asymmetry with respect to both the direction and magnitude of oil price shock. Then, we estimate both LVSTR and EVSTR models for each of our GCC countries. This is a more practical way to determine what kind of asymmetry is actually driving the oil-stock relationship. In each case, the best specification is selected with respect to the misspecification test.

Table 3. Linearity tests

	$\min(H_0)$	$s_{4,t}$	H_{04}	H_{03}	H_{02}	Form
Bahrain	6.535×10^{-5}	or_{t-4}	2.037×10^{-2}	5.304×10^{-2}	2.609×10^{-4}	Logistic
Kuwait	1.437×10^{-3}	or_{t-4}	3.239×10^{-2}	1.323×10^{-1}	1.652×10^{-3}	Logistic
Oman	1.258×10^{-2}	or_{t-6}	2.145×10^{-1}	2.081×10^{-2}	2.863×10^{-2}	Exponential
Qatar	1.881×10^{-4}	or_{t-5}	8.293×10^{-3}	9.637×10^{-4}	2.274×10^{-1}	Exponential
Saudi Arabia	3.226×10^{-2}	or_{t-3}	1.332×10^{-1}	3.578×10^{-2}	2.918×10^{-1}	Exponential
UAE	1.336×10^{-1}	or_{t-3}	9.407×10^{-2}	2.688×10^{-1}	7.828×10^{-1}	Linear

Note: This table shows p-values derived from the linearity tests. The null assumption of linearity H_0 is tested against the alternative of nonlinear STR model. In the second column, the smallest p-value is indicated with the corresponding lagged transition variable, $s_{4,t} = or_{t-i}$. Next, the p-values of the sequential nested null hypotheses (H_{04}, H_{03}, H_{02}) are reported in the fourth, fifth, and sixth columns, respectively. The relevant transition function is given in the last column. The rule for this procedure is the following: If the p-value corresponding to H_{03} is the lowest among H_{04}, H_{03}, H_{02}, we choose the exponential specification. If not, the logistic form is preferred.

[27] The Saudi stock market experienced a rigorous crash in 2006 after the stock price index collapsed, losing roughly 65 percent of its value. This could possibly be considered an outlier when conducting linearity tests. To check for robustness, we have tested for smooth transition nonlinearity by adjusting for outliers using iterated weighted least squares, as in van Dijk et al. (1999). The obtained results are quite similar to those reported in Table 3. The results are not reported here in order to save space, but are available upon request.

5.2. Asymmetry Between Positive and Negative Oil Price Changes

We begin by investigating whether stock returns in GCC countries respond asymmetrically to oil price decreases and increases. To capture the asymmetry arising from the direction of oil price shock, we implement the LVSTR specification, which is appropriate for separating oil price into positive and negative changes. We expect negative oil price changes to have larger impacts on stock returns than their positive counterparts (Sim and Zhou, 2015, and Mohanty et al., 2011). This is valid for oil-exporting countries. The responses of equity prices to negative oil deviations could be higher as corporations' earnings are further lower following a decrease in the industrial activity. The NLS estimates obtained from equation (4) of our LVSTR model are reported in Table 4. We indicate the long-run effect of oil prices for each of the two extreme regimes, namely, for negative oil shock when $G_4(or_{t-i}; \gamma_4, c_4) = 0$, and for positive oil shock when $G_4(or_{t-i}; \gamma_4, c_4) = 1$.[28] As we investigate the oil-stock prices nexus, only oil price changes are allowed to have regime-switching behavior driving by the dynamic of transition function. As discussed above, diagnostic tests have been performed to check the quality of the estimated nonlinear models. The selected VSTR models pass the main misspecifications tests, i.e., no error autocorrelation, parameter constancy, and no remaining nonlinearity. In Table 4, we provide results only for countries for which linearity is rejected, specifically, all GCC countries except the UAE.

As for the estimated long-run effects of oil price changes, we find that stock return responses are not statistically significant in Bahrain across the two regimes (for negative and positive oil price changes). Bahrain's stock market is the smallest, having the lowest liquidity among the six GCC countries; this would explain the lack of linkage to the oil crude market. Also, Bahrain is the least reliant on oil among the GCC countries, with oil rents corresponding to only 2.3 percent of GDP (see Figure 1). In addition, Table 4 reveals that negative (or small positive) oil price changes have significant effects on the equity market returns of Kuwait, Oman, Qatar, and Saudi Arabia. For instance, when an oil variation is below the threshold of 8.6 percent ($\hat{c}_4 = 0.086$), the response of Qatar's stock return to a 1 percent oil change is equal to 0.33 percent. For Oman, stock return increases by roughly 0.5 percent for a negative or small oil price deviation, being below the threshold of 9.3 percent ($\hat{c}_4 = 0.093$). In the case of

[28] Lags on MSCI World Index returns, US three-month T-bills, and GPR index are generally found to be statistically insignificant across different estimated models. Hence, we retain only one lag coefficients for these variables in the selection of our final specification.

Kuwait, when the oil price changes are negative and below the threshold of $\hat{c}_4 \simeq -0.096$ ($or_{t-4} < -0.096$), i.e., for large oil price decrease, the response of the stock return is equal to 0.70 percent. Significant impact of negative oil price change is also recorded for Saudi Arabia, where the stock return elasticity is equal to 0.66 percent.

It is important to note that only Kuwait shows a significant reaction to stock price (about 0.48 percent), when oil price change is above the estimated threshold ($or_{t-4} > -0.096$), i.e., for small oil price decrease and positive oil price changes. As shown in Table 4, Kuwait's stock market exposure to oil price change is significantly unequal across the two regimes. This result is consistent with Basher *et* al. (2018), for whom the presence of regime-switching behavior is found for oil-exporting countries such as Kuwait. Nevertheless, our results reveal that when oil price changes are higher than the estimated thresholds in Oman, Qatar, and Saudi Arabia, the responses of stock price returns are weak and not significant.

To clarify the picture in Kuwait's case, we plotted both the estimated logistic functions and the stock return responses as functions of lagged oil returns ($\hat{s}_{4t} = or_{t-i}$) in Figure A1 in Appendix.[29] The plotted logistic transition function is an increasing function of the transition variable $\hat{s}_{4t} = or_{t-i}$, and is obtained using the estimated values of $\hat{c}_4$ and $\hat{\gamma}_4$ as $G_4(or_{t-i}; \gamma_4, c_4) = [1 + exp\{-\gamma_4(or_{t-i} - c_4)\}]^{-1}$. Similarly, the stock return response depends on the value taken by $\hat{s}_{4t} = or_{t-i}$, and is calculated using the formula for the long-run impact of oil return: $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\, G_4\left(s_{4,t}; \gamma_4, c_4\right)\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. As shown in Figure A1, the transition between both extreme regimes, $G_4(or_{t-i}; \gamma_4, c_4) = 0$ and $G_4(or_{t-i}; \gamma_4, c_4) = 1$, is, to some extent, sharp for Kuwait. Also, after observing Figure A1, we note that the reaction of the stock market is higher in negative oil shock cases. To gain further insight into the responses of GCC stock returns to oil price decreases and increases, we provide the plots of long-run oil effect estimates over time in Figure 4, with the estimated threshold levels superimposed. In Figure 4, the long-run oil effect is a time-varying coefficient that depends on the evolution of oil price variation, $\hat{s}_{4t} = or_{t-i}$, over time: $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\, G_4\left(s_{4,t}; \gamma_4, c_4\right)\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$. The displayed plots reveal that each time the oil price variation falls below a given threshold, the stock return's reaction is more pronounced in Kuwait.

[29] Plots for Oman, Qatar, and Saudi Arabia are not displayed because long-run coefficients are not significant for positive oil price deviations.

Table 4. Estimation results using logistic specification

Bahrain

$$sr_t = \underset{(0.576)}{-0.018}\underset{(0.678)}{-0.015}i^{us}_{t-1} + \underset{(0.001)}{0.437}wr_{t-1} + \underset{(0.001)}{0.481}or_{t-2} + \underset{(0.007)}{0.877}or_{t-5}\underset{(0.001)}{-1.306}or_{t-6} + \underset{(0.080)}{0.177}sr_{t-1}$$
$$\underset{(0.047)}{-0.045}gpr^{ksa}_{t-1} + \left(\underset{(0.009)}{-0.462}or_{t-2}\underset{(0.012)}{-0.863}or_{t-5} + \underset{(0.002)}{1.191}or_{t-6}\right) \times G_4(\hat{s}_{4t};\hat{\gamma}_4,\hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t};\hat{\gamma}_4,\hat{c}_4) = \left[1 + \exp\left(\underset{(0.378)}{-7.095}\,(or_{t-4} - \underset{(0.000)}{(-0.092)}\,)\right)\right]^{-1}$

$R^2 = 0.447$; $pLM_{AR(8)} = 0.534$; $pLM_C = 0.589$; $pLM_{NRN} = 0.412$

Negative oil changes: $G_4(or_{t-4};\gamma_4,c_4) = 0$	**Positive oil changes:** $G_4(or_{t-4};\gamma_4,c_4) = 1$
Long-run effect = $\underset{(0.874)}{0.063}$	*Long-run effect* = $\underset{(0.734)}{-0.211}$

Kuwait

$$sr_t = \underset{(0.106)}{0.026} + \underset{(0.365)}{0.027}i^{us}_{t-1} + \underset{(0.000)}{0.480}wr_{t-1} + \underset{(0.000)}{0.386}or_{t-1} + \underset{(0.000)}{0.481}or_{t-2}\underset{(0.374)}{-0.080}sr_{t-3}$$
$$\underset{(0.045)}{-0.177}sr_{t-4}\underset{(0.011)}{-0.062}gpr^{ksa}_{t-1}\underset{(0.001)}{-0.474}or_{t-2} \times G_4(\hat{s}_{4t};\hat{\gamma}_4,\hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t};\hat{\gamma}_4,\hat{c}_4) = \left[1 + \exp\left(\underset{(0.629)}{-11.664}\,(or_{t-4} - \underset{(0.000)}{(-0.096)}\,)\right)\right]^{-1}$

$R^2 = 0.482$ $pLM_{AR(8)} = 0.712$; $pLM_C = 0.289$; $pLM_{NRN} = 0.275$

Negative oil changes: $G_4(or_{t-4};\gamma_4,c_4) = 0$	**Positive oil changes:** $G_4(or_{t-4};\gamma_4,c_4) = 1$
Long-run effect = $\underset{(0.000)}{0.690}$	*Long-run effect* = $\underset{(0.000)}{0.475}$

Oman

$$sr_t = \underset{(0.030)}{0.026} - \underset{(0.091)}{0.040}i^{us}_{t-1} + \underset{(0.048)}{0.118}wr_t + \underset{(0.170)}{0.070}or_t + \underset{(0.467)}{0.036}or_{t-1} + \underset{(0.071)}{0.085}or_{t-2} + \underset{(0.044)}{0.097}or_{t-4}$$
$$+\underset{(0.250)}{0.062}or_{t-6} + \underset{(0.037)}{0.173}sr_{t-1} + \underset{(0.210)}{0.109}sr_{t-2} - \underset{(0.104)}{0.028}gpr^{ksa}_{t-1} + \left(\underset{(0.011)}{0.566}or_{t-1} - \underset{(0.001)}{0.837}or_{t-5}\right)$$
$$\times G_4(\hat{s}_{4t};\hat{\gamma}_4.\hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t};\hat{\gamma}_4,\hat{c}_4) = \left[1 + \exp\left(\underset{(0.223)}{-9.481}\,(or_{t-6} - \underset{(0.000)}{0.093}\,)\right)\right]^{-1}$

$R^2 = 0.550$; $pLM_{AR(8)} = 0.324$; $pLM_C = 0.385$; $pLM_{NRN} = 0.341$

Negative oil changes: $G_4(or_{t-6};\gamma_4,c_4) = 0$	**Positive oil changes:** $G_4(or_{t-6};\gamma_4,c_4) = 1$
Long-run effect = $\underset{(0.001)}{0.488}$	*Long-run effect* = $\underset{(0.721)}{0.110}$

Table 4. *Continued*

Qatar

$$sr_t = \underset{(0.009)}{0.056} - \underset{(0.471)}{0.069} i^{us}_{t-1} - \underset{(0.067)}{0.044} wr_{t-1} + \underset{(0.046)}{0.201} or_{t-1} + \underset{(0.106)}{0.148} or_{t-3} + \underset{(0.527)}{0.067} sr_{t-1} - \underset{(0.218)}{0.122} sr_{t-2}$$
$$-\underset{(0.022)}{0.079} gpr^{ksa}_{t-1} + \left(\underset{(0.459)}{0.286} or_{t-1} - \underset{(0.386)}{0.299} or_{t-2} - \underset{(0.950)}{0.019} or_{t-3} - \underset{(0.131)}{0.967} or_{t-5} + \underset{(0.264)}{0.351} or_{t-6}\right)$$
$$\times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $$G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = \left[1 + \exp\left(-\underset{(0.272)}{3.183} \left(or_{t-5} - \underset{(0.047)}{0.086}\right)\right)\right]^{-1}$$

$R^2 = 0.616$; $pLM_{AR(8)} = 0.941$; $pLM_C = 0.406$; $pLM_{NRN} = 0.452$

Negative oil changes: $G_4(or_{t-6}; \gamma_4, c_4) = 0$	**Positive oil changes:** $G_4(or_{t-6}; \gamma_4, c_4) = 1$
Long-run effect = $\underset{(0.015)}{0.331}$	*Long-run effect* = $\underset{(0.594)}{0.266}$

Saudi Arabia

$$sr_t = -\underset{(0.629)}{0.018} + \underset{(0.601)}{0.012} i^{us}_{t-1} + \underset{(0.000)}{0.495} wr_{t-1} + \underset{(0.116)}{0.193} or_{t-1} + \underset{(0.012)}{0.271} or_{t-2} + \underset{(0.415)}{0.077} sr_{t-1} + \underset{(0.217)}{0.109} sr_{t-4}$$
$$+\underset{(0.231)}{0.110} sr_{t-5} - \underset{(0.043)}{0.077} gpr^{ksa}_{t-1} + \left(-\underset{(0.045)}{0.804} or_{t-1} + \underset{(0.069)}{0.877} or_{t-2} - \underset{(0.479)}{0.196} or_{t-3}\right)$$
$$\times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $$G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = \left[1 + \exp\left(-\underset{(0.376)}{3.656} \left(or_{t-3} - \underset{(0.078)}{0.061}\right)\right)\right]^{-1}$$

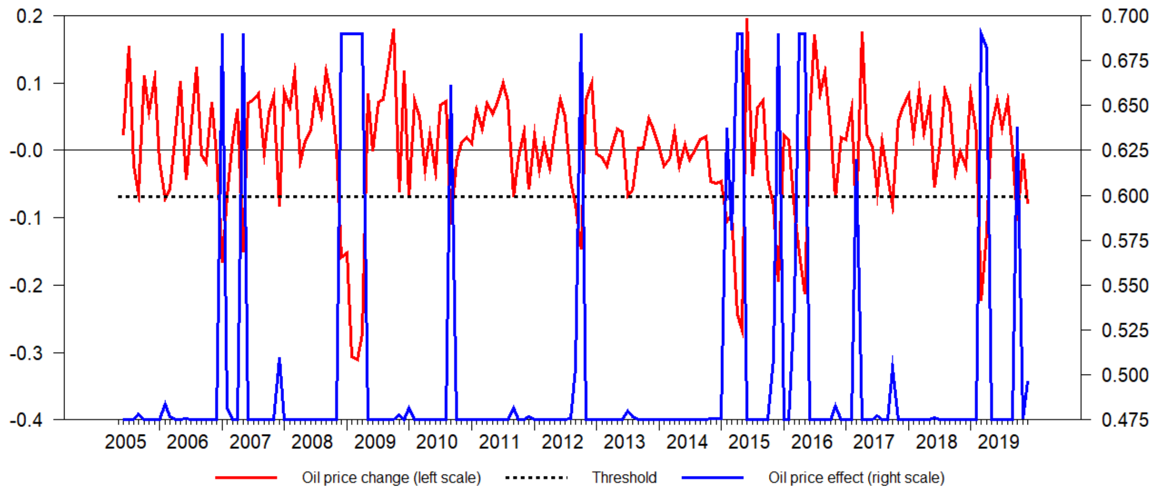
$R^2 = 0.514$; $pLM_{AR(8)} = 0.968$; $pLM_C = 0.362$; $pLM_{NRN} = 0.271$

Negative oil changes: $G_4(or_{t-3}; \gamma_4, c_4) = 0$	**Positive oil changes:** $G_4(or_{t-3}; \gamma_4, c_4) = 1$
Long-run effect = $\underset{(0.010)}{0.659}$	*Long-run effect* = $\underset{(0.418)}{0.483}$

Notes: The estimation results are derived from equation (4) of the VSTR system using the logistic form as a transition function. Long-run effects are the impact of oil price change for negative oil price deviations, that is, when $G_4(s_{4t}; \gamma_4, c_4) = 0$, and for positive oil deviations, that is, when $G_4(s_{4t}; \gamma_4, c_4) = 1$. . R^2 indicates the coefficient of determination. p-values of the estimates are reported between parentheses. $pLM_{AR(8)}$, pLM_C, and pLM_{NRN} are the p-values of LM-type tests of no error autocorrelation, parameter constancy, and no remaining nonlinearity, respectively.

Indeed, when using the LVSTR specification, the estimated threshold should be very close to zero ($\hat{c}_4 \simeq 0$) in order to determine whether an oil price change is positive or negative. However, in most cases, our LVSTR models provide estimated thresholds that are, to some degree, different from the expected threshold level of $\hat{c}_4 \simeq 0$, ranging from $\hat{c}_4 \simeq -0.10$ in Kuwait to $\hat{c}_4 = 0.096$ in Oman. This might explain why we do not find significant asymmetric effects for positive and negative oil price changes on stock returns for most of our GCC countries. Finally, it is worth noting that the introduction of the GPR index in the empirical model plays a significant role in the oil-stock relationship. As expected, the rising of geopolitical tensions in Saudi Arabia, as the most important country in the region, negatively influences the GCC stock markets.[30]

Figure 4. Time-varying impacts of oil prices on stock returns using logistic specifications



Kuwait

Note: The y-axis indicates time-varying long-run oil price effects (right scale), oil returns (left scale), and threshold levels (right scale). The x-axis: the monthly time index from 2005–2019. Time-varying long-run oil impacts on GCC stock returns are obtained using the following formula: $[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\, G_4(s_{4,t};\gamma_4, c_4)]/[1 - \sum_{i=1}^{N} \beta_{i,4,4}]$, with $G_4(or_{t-i};\gamma_4, c_4) = [1 + exp\{-\gamma_4(or_{t-i} - c_4)\}]^{-1}$.

Overall, when considering the presence of asymmetry with respect to oil price direction, there is a great deal of diversity among GCC countries' stock market responses. To some extent, only Kuwait corroborates the conventional wisdom that negative oil price deviations have greater impacts on equities than positive oil price changes do. The strong link between Kuwait's equity market and the global factors would make equities sensitive across different regimes. For Oman, Qatar, and Saudi Arabia, stock returns are only significant for negative or small positive deviations, but for Bahrain, stock market reactions are not significant for either regime. In the next step, we investigate whether the EVSTR specification could be more effective at capturing the presence of asymmetry and regime-switching behavior with respect to the size of oil price changes in the GCC region.

[30] In a recent study, El-Gamal and Jaffe (2018) have revealed that military conflicts have the most significant disruptions on Middle East oil supply, while nonviolent geopolitical tensions have more limited sustained impact.

5.3. Asymmetry Between Small and Large Oil Price Changes

Now, we test whether the effects that large oil price shocks exert on stock prices could be different from the effects caused by smaller shocks. In this case, the EVSTR specification is more relevant for capturing asymmetry with respect to the magnitude of oil price movement. Stock prices are expected to respond asymmetrically to changes in oil prices; large oil prices are associated with higher stock price responses, while small oil price changes would impact fewer stock returns. For the case of the GCC group, fiscal policy may play a key role in explaining the dynamic between oil price and the performances of companies listed on the stock exchange. It is possible that small changes in the oil market may not impact stock returns because governments can cushion the oil shock via countercyclical adjustments, given the availability of fiscal space.

As previously discussed, in the EVSTR specification, the dynamic would be different depending on whether oil change as a transition variable, $\hat{s}_{4t} = or_{t-i}$, is close to or far away from a certain threshold. The results related to the possible asymmetric effects of small and large oil price changes on equity returns in Gulf economies are summarized in Table 5. As shown, the estimated threshold values of oil returns do not differ considerably across our sample in absolute value, ranging from 2 percent in Oman to 5.4 percent in Bahrain, with quite similar values for Qatar and Saudi Arabia, having threshold levels close to 4 percent ($|\hat{c}_4| \simeq 0.04$).

With respect to the long-term effects of oil price changes, our estimations reveal positive correlations between stock return responses and the magnitudes of oil price changes in four Gulf countries, namely Kuwait, Oman, Qatar, and Saudi Arabia. These countries exhibit an asymmetric behavior of equity prices with respect to the magnitude of oil price changes. More specifically, as reported in Table 5, the reaction of the Kuwait stock market is equal to 0.36 percent when oil variation is small and close to 2.7 percent. But for large deviations exceeding the threshold of 2.7 percent, stock markets' sensitivity increases with an elasticity being equal to 0.63 percent. A very similar reaction has been recorded for the case of Oman. We note that Qatar and Saudi Arabia exhibit a large elasticity of equity prices to oil shocks, which is close to unity. As shown in Table 5, for Saudi Arabia the impact of Brent oil prices is not significant when changes are small and close to 4.7 percent (the threshold being $|\hat{c}_4| = 0.047$). For a higher oil price change ($|or_{t-6}| > 4.7\%$), oil price changes exert a lager effect on stock returns corresponding to 0.95 percent. Similarly, with considerable price variations (greater than the threshold level of 4 percent), oil price changes exert larger, significant long-run effects on Qatar's stock returns at 0.94 percent. It is interesting to note that all the four countries' economies (Kuwait, Oman, Qatar, and Saudi Arabia) are inadequately diversified, having the highest ratios of hydrocarbon fiscal revenue to total revenue.

For the case of Bahrain, however, the stock prices' long-run responses to substantial oil price changes turn out to be statistically insignificant. Once again, the absence of asymmetric behavior with respect to changes in the oil market is confirmed. On the opposite side, Kuwait has shown the presence of two types of asymmetry, namely, with respect to the direction and magnitude of oil price change. The degree of the country's dependence on oil seems to be an important factor in explaining this outcome. The heavy reliance of Kuwait on oil revenues would make it more sensitive to changes in oil price.

Figure A2 in Appendix provides additional evidence for the presence of asymmetry arising from the degree of oil price variation.[31] High oil price changes in absolute values elicit greater reactions from equity prices than small oil price variations do. Finally, to gain more insight into the relationship between stock return and the magnitude of oil price change, we plot the time-varying coefficients over the period 2005–2019 in Figure 5. Since our study covers the episode of dramatic oil price increases throughout 2007 and early 2008, it is evident that stock return sensitivity was significantly higher than it was during periods of small price changes. In the same way, the oil price plunge of 2014-2015 has impacted considerably equity returns in the Gulf region, with Qatar and Saudi Arabia having the most pronounced reactions.

[31] Plots for Bahrain are not displayed because the long-run coefficients are not significant for large oil price changes.

Table 5. Estimation results using exponential specification

Bahrain

$$sr_t = \underset{(0.733)}{-0.007} \underset{(0.600)}{-0.019}\, i^{us}_{t-1} + \underset{(0.056)}{0.428} wr_{t-1} + \underset{(0.056)}{0.191} or_{t-1} + \underset{(0.206)}{0.182} or_{t-4} + \underset{(0.165)}{0.144} sr_{t-1} + \underset{(0.173)}{0.128} sr_{t-5}$$
$$\underset{(0.599)}{-0.013} gpr^{ksa}_{t-1} + \left(\underset{(0.152)}{0.833}\, or_{t-2} + \underset{(0.369)}{0.785}\, or_{t-5} \underset{(0.208)}{-1.300}\, or_{t-6} \right) \times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = 1 - \exp\left[\underset{(0.525)}{-0.145} \left(or_{t-4} - \underset{(0.134)}{0.054} \right)^2 \right]$

$R^2 = 0.423$; $pLM_{AR(8)} = 0.234$; $pLM_C = 0.177$; $pLM_{NRN} = 0.384$

Small oil changes: $G_4(or_{t-4}; \gamma_4, c_4) = 0$	**Large oil changes:** $G_4(or_{t-4}; \gamma_4, c_4) = 1$
Long-run effect $= \underset{(0.034)}{0.512}$	*Long-run effect* $= \underset{(0.333)}{0.855}$

Kuwait

$$sr_t = \underset{(0.122)}{0.029} \underset{(0.782)}{-0.009} i^{us}_{t-1} + \underset{(0.000)}{0.535} wr_{t-1} + \underset{(0.029)}{0.440} or_{t-1} \underset{(0.027)}{-0.200}\, sr_{t-4} \underset{(0.025)}{-0.049} gpr^{ksa}_{t-1}$$
$$+ \left(\underset{(0.098)}{-0.359} or_{t-3} + \underset{(0.003)}{0.674}\, or_{t-4} \right) \times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = 1 - \exp\left[\underset{(0.064)}{-3.882} \left(or_{t-4} - \underset{(0.000)}{0.027} \right)^2 \right]$

$R^2 = 0.604$; $pLM_{AR(8)} = 0.923$; $pLM_C = 0.466$; $pLM_{NRN} = 0.422$

Small oil changes: $G_4(or_{t-4}; \gamma_4, c_4) = 0$	**Large oil changes:** $G_4(or_{t-4}; \gamma_4, c_4) = 1$
Long-run effect $= \underset{(0.032)}{0.366}$	*Long-run effect* $= \underset{(0.027)}{0.628}$

Oman

$$sr_t = \underset{(0.017)}{0.038} - \underset{(0.385)}{0.022} i^{us}_{t-1} + \underset{(0.118)}{0.164} wr_{t-1} + \underset{(0.010)}{0.339} or_{t-1} + \underset{(0.658)}{0.048} or_{t-2} - \underset{(0.167)}{0.173} or_{t-3} + \underset{(0.216)}{0.136} sr_{t-1}$$
$$+ \underset{(0.314)}{0.105} sr_{t-2} - \underset{(0.295)}{0.098} sr_{t-6} - \underset{(0.001)}{0.073} gpr^{ksa}_{t-1} + \left(\underset{(0.029)}{0.428} or_{t-1} - \underset{(0.028)}{0.471} or_{t-2} + \underset{(0.176)}{0.222}\, or_{t-3} \right)$$
$$\times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = 1 - \exp\left[\underset{(0.185)}{-1.773} \left(or_{t-6} - \underset{(0.042)}{0.019} \right)^2 \right]$

$R^2 = 0.603$; $pLM_{AR(8)} = 0.768$; $pLM_C = 0.392$; $pLM_{NRN} = 0.355$

Small oil changes: $G_4(or_{t-6}; \gamma_4, c_4) = 0$	**Large oil changes:** $G_4(or_{t-6}; \gamma_4, c_4) = 1$
Long-run effect $= \underset{(0.087)}{0.249}$	*Long-run effect* $= \underset{(0.078)}{0.458}$

Table 5. *Continued*

Qatar

$$sr_t = \underset{(0.011)}{0.069} + \underset{(0.566)}{0.026} i^{us}_{t-1} - \underset{(0.333)}{0.123} wr_{t-1} + \underset{(0.242)}{0.179} or_{t-1} + \underset{(0.008)}{0.500} or_{t-1} - \underset{(0.012)}{0.579} or_{t-2} - \underset{(0.292)}{0.221} or_{t-4}$$
$$+\underset{(0.005)}{0.568} or_{t-6} + \underset{(0.002)}{0.321} sr_{t-1} - \underset{(0.148)}{0.144} sr_{t-2} - \underset{(0.286)}{0.107} sr_{t-3} - \underset{(0.037)}{0.080} gpr^{ksa}_{t-1} + \Big(\underset{(0.238)}{0.279} or_{t-1}$$
$$- \underset{(0.023)}{0.653} or_{t-2} - \underset{(0.002)}{0.902} or_{t-3} - \underset{(0.169)}{0.360} or_{t-4} - \underset{(0.011)}{0.663} or_{t-6}\Big) \times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

with $G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = 1 - \exp\left[-\underset{(0.100)}{1.159}\left(or_{t-5} - \underset{(0.000)}{(-0.041)}\right)^2\right]$

$R^2 = 0.551$; $pLM_{AR(8)} = 0.821$; $pLM_C = 0.766$; $pLM_{NRN} = 0.273$

Small oil changes: $G_4(or_{t-5}; \gamma_4, c_4) = 0$	**Large oil changes:** $G_4(or_{t-5}; \gamma_4, c_4) = 1$
Long-run effect $= \underset{(0.102)}{0.626}$	*Long-run effect* $= \underset{(0.041)}{0.942}$

Saudi Arabia

$$sr_t = -\underset{(0.388)}{0.039} + \underset{(0.442)}{0.013} i^{us}_{t-1} + \underset{(0.000)}{0.490} wr_{t-1} + \underset{(0.143)}{0.309} or_{t-2} - \underset{(0.134)}{0.170} or_{t-4} + \underset{(0.191)}{0.141} or_{t-5} + \underset{(0.213)}{0.104} sr_{t-4}$$
$$+\underset{(0.258)}{0.103} sr_{t-5} + \underset{(0.237)}{0.123} sr_{t-6} - \underset{(0.013)}{0.152} gpr^{ksa}_{t-1} + \underset{(0.076)}{0.355} or_{t-1} \times G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) + \hat{\varepsilon}_{4,t},$$

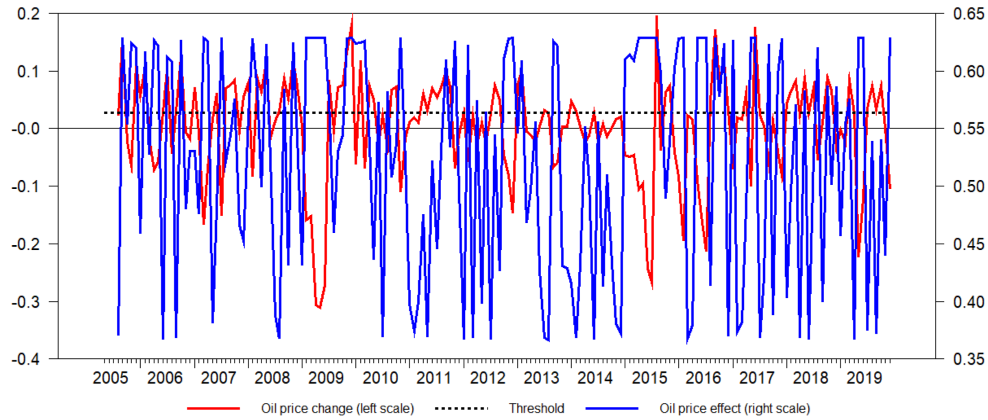
with $G_4(\hat{s}_{4t}; \hat{\gamma}_4, \hat{c}_4) = 1 - \exp\left[-\underset{(0.319)}{2.153}\left(or_{t-3} - \underset{(0.031)}{(-0.047)}\right)^2\right]$

$R^2 = 0.487$; $pLM_{AR(8)} = 0.933$; $pLM_C = 0.453$; $pLM_{NRN} = 0.548$

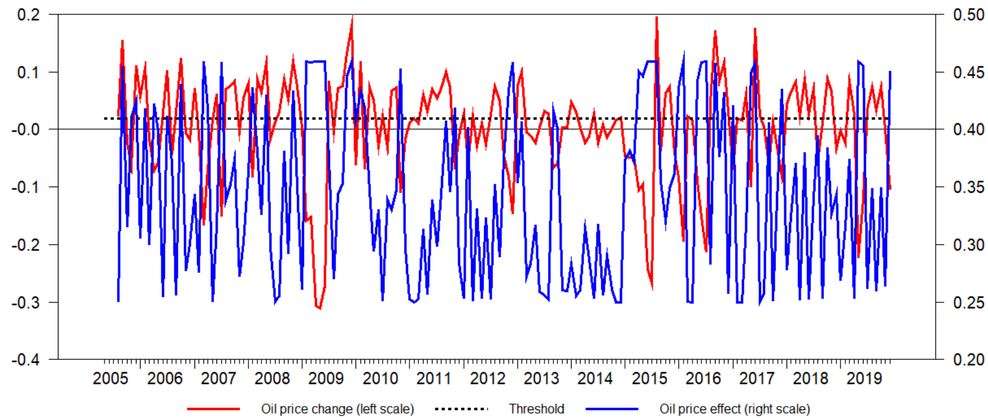
Small oil changes: $G_4(or_{t-6}; \gamma_4, c_4) = 0$	**Large oil changes:** $G_4(or_{t-6}; \gamma_4, c_4) = 1$
Long-run effect $= \underset{(0.389)}{0.417}$	*Long-run effect* $= \underset{(0.051)}{0.947}$

Notes: The estimation results are derived from equation (4) of the VSTR system using the exponential form as a transition function. Long-run effects are the impact of oil price on small oil price changes, that is, when $G_4(s_{4t}; \gamma_4, c_4) = 0$, and for large oil price changes, that is, when $G_4(s_{4t}; \gamma_4, c_4) = 1$. R^2 indicates the coefficient of determination. p-values of the estimates are reported between parentheses. $pLM_{AR(8)}$, pLM_C, and pLM_{NRN} are the p-values of LM-type tests of no error autocorrelation, parameter constancy, and no remaining nonlinearity, respectively.

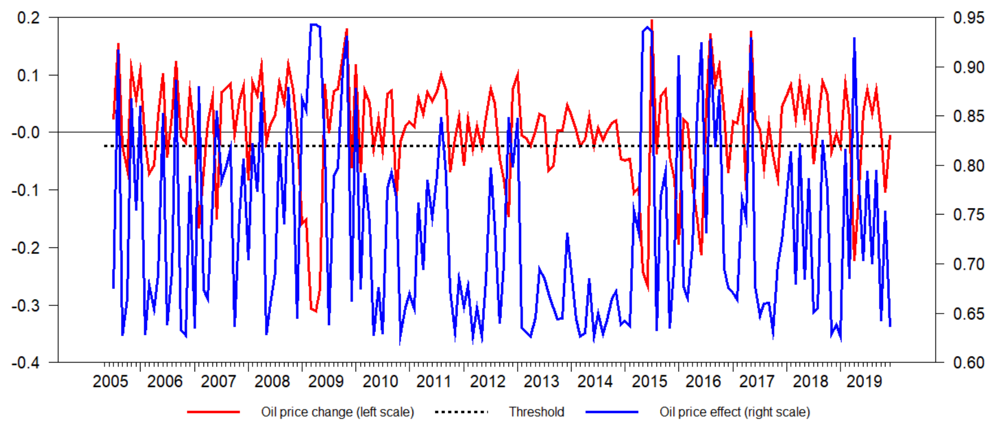
Figure 5. Time-varying impacts of oil prices on stock returns using exponential specifications



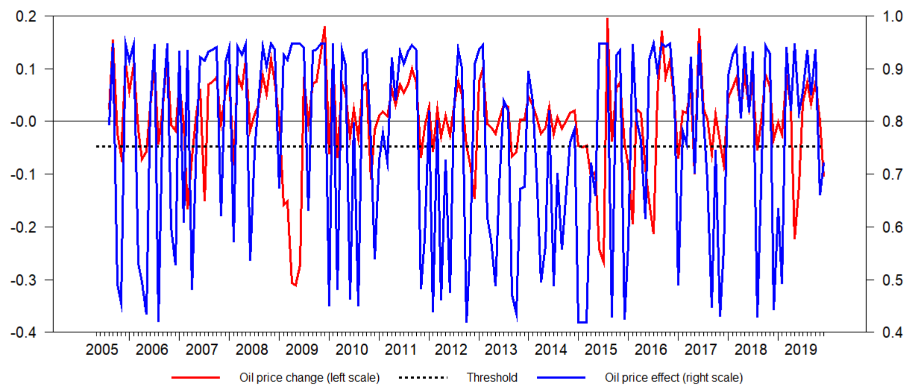
Kuwait



Oman



Qatar



Saudi Arabia

Note: The y-axis reports time-varying long-run oil price effects (right scale), oil returns (left scale), and threshold values (right scale). The x-axis: the monthly time index from 2005–2019. Time-varying long-run oil impacts on GCC stock returns are obtained using the following formula: $\left[\sum_{i=1}^{N}\beta_{i,4,3}+\sum_{i=1}^{N}\phi_{i,4,3}\,G_4\left(s_{4,t};\gamma_4,c_4\right)\right]/\left[1-\sum_{i=1}^{N}\beta_{i,4,4}\right]$, with $G_4(or_{t-i};\gamma_4,c_4)=1-exp\{-\gamma_4(or_{t-i}-c_4)^2\}$.

All in all, our results from the estimated EVSTR models would confirm the important heterogeneity in stock return sensitivities across GCC countries.[32] The relationship between oil price and the stock market can be considered asymmetrical, as well as regime switching, with respect to the magnitude of oil price changes in four GCC countries, Kuwait, Oman, Qatar, and Saudi Arabia. This implies that, in these two countries, large oil price changes exert a greater impact on stock returns than small oil price variations do.

6. Policy Discussion

Previous studies have shown the existence of generally robust relationships between oil prices and stock markets in GCC countries. These findings are expected, given that economic activity and growth in these countries are strongly influenced by their oil export earnings. Despite the apparent common economic and political characteristics shared by GCC countries, they still differ to some degree in their levels of dependency on oil and in their efforts in economic reforms. Our study supports the presence of heterogeneous profiles in the reaction of GCC stock markets to oil price changes, in the sense that this sensitivity is asymmetric for some countries, but not for others. These dissimilarities confirm that GCC countries being

[32] Using a structural vector auto-regression (SVAR) model to study the effect of oil price on economic activity, Nasir et al. (2019) revealed substantial heterogeneities across the GCC members. The authors argued that this outcome is due to differences in the degree to which these economies are dependent on oil revenues.

inadequately diversified are prone to react asymmetrically to oil-market changes. This result has important implications for both investors and policymakers.

From an investment strategy perspective, our results underscore the importance for market participants to consider differences in the sensitivities of stock returns to oil prices across GCC countries when deciding on the compositions of international stock portfolios. As highlighted in other studies, there can be substantial potential benefits to including stocks from GCC countries in portfolios that also include stocks from net oil importing countries, given that the latter group generally exhibits negative sensitivities to oil price changes. Our research emphasizes the importance of accounting for differences in stock return sensitivities across GCC countries, including potential asymmetric behaviors, when making portfolio diversification decisions and developing oil-price-related hedging strategies. The signs and magnitudes of the oil price shocks are country specific and hence opportunities for portfolio diversification exist. Although GCC markets are still promising areas for international portfolio diversification, global investors need to be aware and should consider significant heterogeneous reactions in their respective financial assets. It is worth highlighting that the GCC markets still have limited market access to foreign investors and low liquidity although the wave of financial reforms engaged in the last two decades. Stock market liquidity has been restricted by public ownership of a substantial share of GCC equities and limited secondary market trading activities. However, there remains a substantial room to further enhance stock market efficiency and reduce equity prices sensitivity to shocks. Additional reforms should concentrate on strengthening corporate governance and investors protection, eliminating foreign ownership restrictions, and fostering competition in the financial market.

From a policy perspective, our framework could serve to identify countries in which asymmetries prevail, where policy action would be especially beneficial from the economic stabilization and reform perspectives. These include policies that ensure consistency with fiscal sustainability and intergenerational equity goals, as well as structural reforms that diversify economic and revenue bases. In GCC countries' equity markets, most stocks are held in domestic nonoil companies.[33] Therefore, from a policymaker's viewpoint, stabilizing the impact of oil price change on nonoil growth is key. The main channel for such stabilization has been fiscal policy, given the GCC group's adherence to the exchange rate peg, particularly through public expenditure policy, and in view of the fledgling taxation system. Ongoing and expected structural reforms are important because they serve to diversify the economic base and increase nonoil sources of financing, thereby reducing the expected sensitivity of nonoil growth to oil-related influences over time. To illustrate, in the case of an oil price decline (the opposite channels operate for an oil price increase), oil revenue falls, leading to weaker fiscal and external positions. Equity returns fall to the extent that market participants expect an adverse impact on nonoil growth, of which the expected fiscal adjustment (especially government spending) is a key determinant. In terms of structural reform signals, all six GCC countries have set out broadly similar reform plans in the aftermath of the 2014-2015 oil price decline. They have also made progress in setting out and clearly communicating credible, well-defined medium-term fiscal frameworks. Within each framework, an important objective has been the implementation of adjustment policies that are supported by structural reforms to diversify their economies away from the hydrocarbon sector, and expand the contribution of the private sector.

7. Concluding Remarks

This paper investigates the asymmetric mechanisms in stock markets' responses to oil price changes. We propose to implement a relevant econometric method that enables us to explore the two possible sources of asymmetry in stock price reactions: the direction and magnitude of oil price change. We use the class of nonlinear STR models, where different regimes can be

[33] Saudi Arabia's equity market is notable in the GCC, in that it also has significant direct exposure to the oil sector through stocks in the domestic petrochemical sector. Nevertheless, over three-quarters of Saudi market shares are in nonoil companies.

identified with respect to estimated thresholds. To capture the asymmetry arising from the direction of oil price shock, we use the LVSTR, which is appropriate for separating oil price into positive and negative changes. However, the EVSTR is more suitable for distinguishing between large and small oil price changes when capturing asymmetric behavior with respect to the size of oil price movement.

Our study includes six GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the UAE), and uses monthly data from January 2005–December 2019. For the oil-stock returns nexus, linearity tests are performed revealing a strong evidence for the presence of nonlinearity in the GCC group, except for the UAE. When investigating the presence of asymmetry with respect to the direction of oil price change, our results reveal a great deal of diversity in the individual responses of GCC stock markets. For example, only Kuwait's stock market reactions to oil price changes are not significantly equal for both rising and falling oil prices. However, equity markets in Oman, Qatar, and Saudi Arabia are found to be sensitive only for negative oil deviations. The EVSTR specification, which helps us to examine asymmetry with respect to oil price change's magnitude, confirms the presence of strong asymmetric reaction in four GCC equity markets. More specifically, we find that Kuwait, Oman, Qatar, and Saudi Arabia stock markets exhibit higher sensitivities to large oil price changes than to small ones. For the case of Bahrain, there is no evidence of asymmetry in stock price reaction, neither for the direction nor for the magnitude of oil price change. Finally, we think that there is room to extend our analysis for future research. The asymmetric mechanisms in stock markets' responses to oil price variations in GCC countries are likely to be different across various economic sectors. Therefore, a disaggregated sectoral analysis of this link could provide additional insight and complement our analysis.

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Appendix

Table A1. Threshold cointegration test

	Bahrain	Kuwait	Oman	Qatar	Saudi Arabia	UAE
ρ_1	-0.074	-0.313	-0.080	-0.077	-0.065	-0.053
	(-1.366)	(-1.524)	(-1.580)	(-1.552)	(-1.507)	(-1.691)
ρ_2	-0.123	-0.407	-0.180	-0.108	-0.104	-0.074
	(-1.654)	(-1.794)	(-2.486)	(-2.023)	(-2.126)	(-1.909)
t-Max	-1.366	-1.524	-1.580	-1.552	-1.507	-1.691
Φ (H_0: $\rho_1 = \rho_2 = 0$)	2.185	2.336	4.187	3.070	3.354	3.170

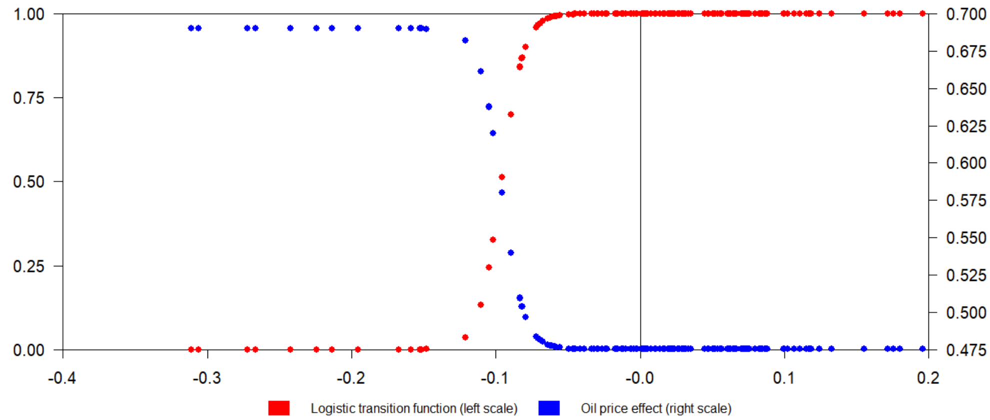
Note: ρ_1 and ρ_2 are the speed of adjustment coefficients in the upper and lower regimes, respectively. t-Max is the largest of t-statistic for the null hypotheses $\rho_1 = 0$ and $\rho_2 = 0$. Φ is the F-statistic for the joint hypothesis $\rho_1 = \rho_2 = 0$. Critical values for t-Max and Φ statistics are provided by of Enders and Siklos (2001). If t-Max is less than -2.55, -2.11, or -1.90, the null of no cointegration is rejected for 1%, 5%, 10% statistical significance levels, respectively. If Φ exceeds the critical values of 8.24, 5.98, or 5.01, then, the null of no cointegration is rejected for 1%, 5%, 10% significance levels, respectively. Enders and Siklos (2001) have shown that Φ have substantially more power than the t-Max statistic. ***, **, and * denote the rejection of the null of no cointegration at significance levels of 1%, 5%, and 10%, respectively. Numbers between parentheses are t-statistics.

Table A2. Lag length selection

Criterion	Suggested Lag Length					
	Bahrain	**Kuwait**	**Oman**	**Qatar**	**Saudi Arabia**	**UAE**
AIC	8	6	2	4	4	2
BIC	1	2	2	4	4	2
LM	8	8	6	8	6	2
HQ	6	8	6	8	8	6

Note: To check the appropriate lag structure in the VSTR system, the following information criteria are tested: Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Lagrange Multiplier (LM) test for residual serial correlation, and Hannan–Quinn Information Criterion (HQ), using maximum lag length $N = 8$.

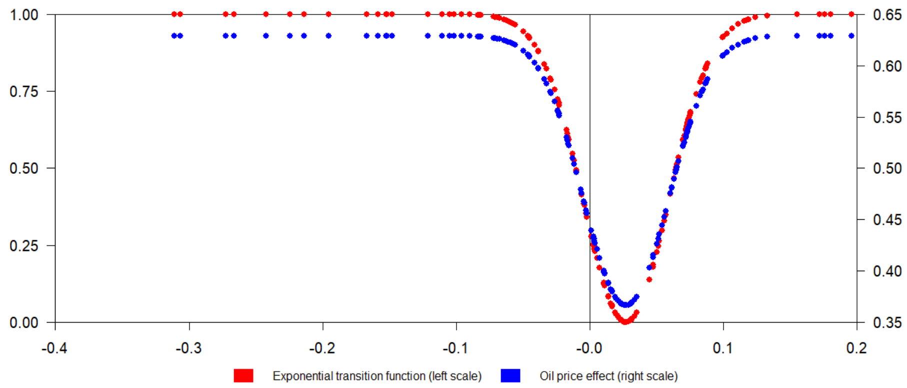
Figure A1. Logistic functions and long-run effects of oil prices



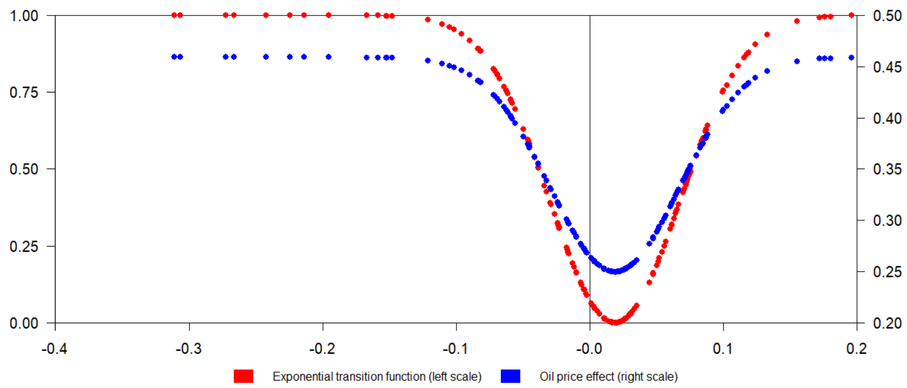
Kuwait

Note: The estimated logistic functions and long-run oil return impacts on stock markets are plotted on the y-axis. The x-axis features/includes the different values taken by the transition variable, $s_{4,t} = or_{t-i}$. The estimated logistic function is calculated using $G_4(or_{t-i};\gamma_4,c_4) = [1 + exp\{-\gamma_4(or_{t-i} - c_4)\}]^{-1}$. The long-run oil impact on stock return is obtained from the following formula: $\left[\sum_{i=1}^{N}\beta_{i,4,3} + \sum_{i=1}^{N}\phi_{i,4,3}\, G_4\left(s_{4,t};\gamma_4,c_4\right)\right]/\left[1 - \sum_{i=1}^{N}\beta_{i,4,4}\right]$.

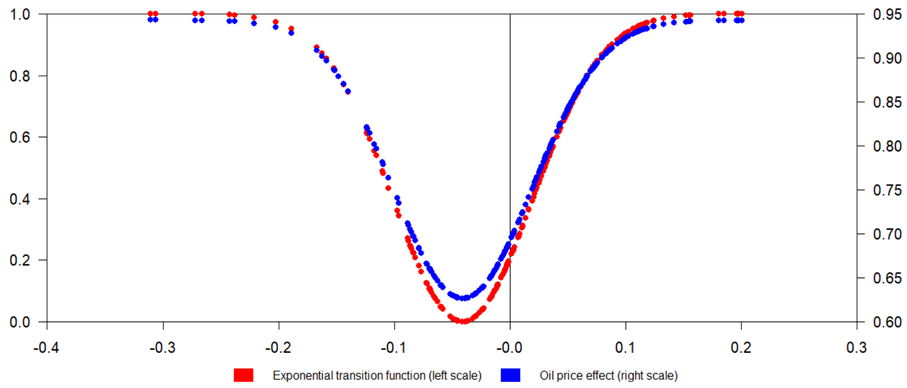
Figure A2. Exponential functions and long-run effects of oil prices



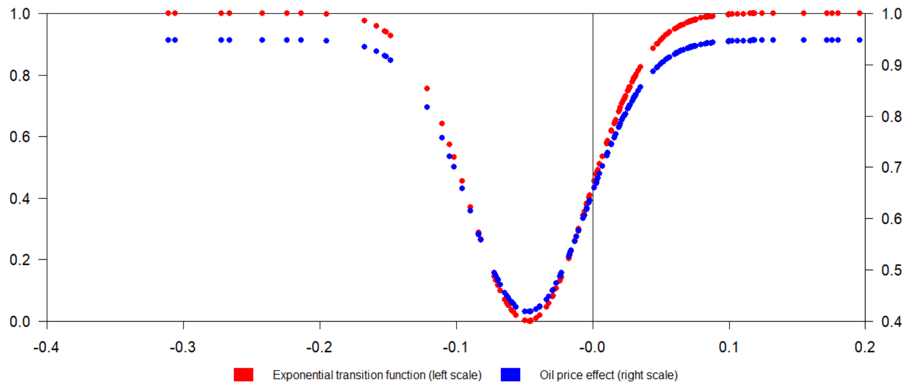
Kuwait



Oman



Qatar



Saudi Arabia

Note: The estimated logistic functions and long-run oil return impacts on stock markets are plotted on the y-axis. The x-axis features/includes the different values taken by the transition variable, $s_{4,t} = or_{t-i}$. The estimated logistic function is calculated using $G_4(or_{t-i}; \gamma_4, c_4) = 1 - exp\{-\gamma_4(or_{t-i} - c_4)^2\}$. The long-run oil impact on stock return is obtained from the following formula: $\left[\sum_{i=1}^{N} \beta_{i,4,3} + \sum_{i=1}^{N} \phi_{i,4,3}\, G_4\left(s_{4,t}; \gamma_4, c_4\right)\right] / \left[1 - \sum_{i=1}^{N} \beta_{i,4,4}\right]$.