Dynamic Effects of Crude Oil Price Movements: a Sectoral Examination

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Abstract

The study employs the Markov switching regression to examine the dynamic effects of crude oil price movements on sector returns in Saudi Arabia, the United Arab Emirates, China and India given the impact of the global factor. The evidence from the Markov switching model with dynamic transitions indicates that crude oil and the global factor are significant in explaining the dynamic transition between the specified regimes. We find that the expected regime durations in India are the highest across the sample. We observe that the consumer durables and construction sectors in India exhibited the longest expected duration in stable regimes, whereas the banking sector lasted much longer in recessions.

Keyword: Markov; recession; regime; stable; transition.

JEL Classification: F01, E2, G2, G15,Q43

1. Introduction

A reflection on the status of crude oil in the global energy mix indicates that crude oil is the single most sought after energy source worldwide. Over the course of the past century, energy – and in particular, crude oil – has been an essential fuel of economic growth and development for both exporting and importing countries (Demirer et al. 2015). Historically, crude oil has exhibited far more shocks and volatility than other assets and commodities, with profound effects (Hamilton 1983, 2003). There has been a plethora of studies (see inter alia Jones and Kaul 1996; Huang et al. 1996; Sadorsky 1999; Papapetrou 2001; Huang et al. 2005; Park and Ratti 2008; Miller and Ratti 2009) that have examined the empirical association between crude oil price shocks and stock returns following Hamilton (1983)[1]. The remainder of this article is structured as follows. Section 2 presents a brief literature review while section 3 gives the approach to the data analysis and

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[1] Hamilton (1983) found a negative association between oil price shocks and the macro economy with overwhelming evidence that indicates that nine of the 10 post-war recessions in the United States were preceded by crude oil price shocks.

methodological path followed. Section 4 and 5 present the empirical results and concluding remarks.

2. Literature Review

There are few studies examining the empirical linkage between crude oil price shocks and stock market returns on sector-specific level. Studies in this regards have focused on the advanced market of the United State (US), Europe and the G7 market at large (see inter alia Mohanty, 2010; Elyasini et al. 2011; Arouri et al. 2011; Arouri, 2011; Narayan and Sharma, 2011; Lee et al. 2012; Fan and Jahar-Parvar, 2012; Degiannakis et al. 2013 and Cunado and Perez de Gracia, 2014). A few other studies on the other hand such as Mohanty et al. (2011), BroadStock and Filis (2014) and Hamman et al. (2014) focused on the Gulf Cooperation Council (GCC) markets and other emerging economies.

Mohanty et al. (2011) examined crude oil price shocks and stock market returns for the oil and gas sector in five Central and Eastern European countries on the bases of firm specific data from December 1998 to March 2010. This study is based on monthly stock returns data. It founds that crude oil price exposure for some oil and gas firm varies at the firm level and across time period. Elyasini et al. (2011) employing the GARCH (1,1) model studied the dynamic effects of crude oil returns and crude oil return volatility on excess equity market returns and return volatilities across thirteen industry in the U.S. The study used a daily data from 11 December 1998 to 29 December 2006. It found that crude oil price movement triggers a systemic risk factor for asset prices at sector specific level for nine of the thirteen sectors examined. It also reports a dissimilar pattern in the effect of crude oil future returns across the sectors studied.

Arouri et al. (2011) adopted a VAR-GARCH technique to study the impact of volatility transmission from crude oil to equity market in Europe and the U.S using sector indices. They found evidence of both unidirectional (in Europe) and bidirectional (in the U.S) spillover in volatility from crude oil to the sector returns indexes examined. The study also reveals heterogeneity in the cross-effect of volatility for the various sector level data examined. Furthermore, Arouri (2011) using a weekly data over a period of January 1 1998 to June 30 2010 employing both linear and asymmetric model further examined the responsiveness of European sector specific equity market indices to crude oil price changes. The study aims to determine the correlation amongst the variables studied for the respective sectors examined. Thus, the findings reveal additional evidence of significant asymmetry in crude oil price movement on the sector returns. Narayan and Sharma (2011) using daily data set within the GARCH (1.1) model also studied the correlation between crude oil price and equity returns for some 560 firms in the U.S. The study found that crude oil price affects firm equities differently based on the sector for which they were located. Interesting, their study reveals that the impact of the crude oil price was sensitive to the dynamic regime pattern for some of the markets examined. Finally, Hamman et al. (2014) examined the effect of crude oil price volatility on the stock market returns in Tunisia. The study used weekly data within a bivariate GARCH-BEKK model from April 2 2006 to July 12 2012. Findings from the study reveals a significant crude oil price shock and volatility spillover across the sector studied with varying intensities. It also maintain a unidirectional spillover of volatility from crude oil to the equity markets.

3. Data and Methodology

This study employs weekly stock data. The start dates for the sample estimation date ranges are 2003/9/3 for the United Arab Emirates and India, 2005/1/5 for China, and 2007/10/17 for Saudi Arabia. The end dates are 2016/1/27 for the whole sample. These ranges are determined by the availability of the data, which were retrieved from DataStream. Thus, for each of the stock markets under study – namely, for Saudi Arabia, the Saudi stock exchange (Tadawul); for the United Arab Emirates, the Abu Dhabi stock exchange; for China, the Shenzhen stock exchange; and for India, CNX Nifty – we obtained the price series for the respective sectors of interest for the current study. These include the following: the banking and financial services, agriculture and food, and the industrial sectors for Saudi Arabia; the banking, food and industrial sectors for the United Arab Emirates (UAE); the financial services, food and industrial sectors for China; and the banking, consumer durables and construction sectors for India. The Brent crude oil price is chosen as a measure of crude oil price movement because it accounts for more than 60 per cent of global crude production, which corresponds to approximately 2/3 of global transactions in crude oil (see Maghyereh 2004; Filis et al. 2011; Arouri et al. 2011; Degiannakis et al. 2013; Ghosh and Kanjilal 2014). We also include data regarding the S&P 500 Volatility index reported by the Chicago Board of Option Exchange (CBOE) to control for the global factor in our model.

3.1 Methodolical approach to data analysis

The Markov switching model is specified following Hamilton's (1989) original model but incorporating switching intercepts in addition to switching regressors.

$$r_t = A_{st} + \sum_{C=1}^{k} B_{st}\, Cr_{t-k}{}^{oil} + \sum_{F=1}^{l} D_{st}\, Fv_{t-l}{}^{gf} + \varepsilon_t \qquad (4)$$

$\varepsilon_t \sim N(0, \sigma_{st}{}^2)$

The terms A_{st} and $\sigma_{st}{}^2$ are the intercept and variance of the sector specific return, respectively, whereas $B_{st}C$ gives the alternative effect crude oil returns have on sector returns in different regimes and *gf* reflect the global economic factor. The term s_t is a latent unobserved state variable that takes values of 1 and 2. Following other empirical studies[2], we specify two regimes defining the state of the economy, i.e., the stable regime in state 1 and the recession regime in state 2. The probability matrix for the unobserved latent state variable obeys the following Markov chain process: $P - \begin{bmatrix} P11 & 1-P22 \\ 1-P11 & P22 \end{bmatrix}$

where $P11 = P(S_t = {}^1/_{S_{t-1}} = 1)$; and $P22 = P(S_t = {}^2/_{S_{t-1}} = 2)$

Based on the original Hamilton specification, the transition probability matrix was initially allowed to be constant and subsequently time-varying to examine the impact of crude oil price changes on the regime probability given the impact of the global factor.

The value of the likelihood function for the unobserved latent variable is specified as follows:

$$F(r_t/s_t = j, \Omega_{t-1}; U_t) = \frac{1}{\sqrt{2\pi\sigma j}} \exp\left[-\frac{1}{2}\left(\frac{r_t - C_{st} - \sum_{c=1}^{k} B_{st} C r_{t-k}{}^{oil} - \sum_{F=1}^{l} D_{st} F v_{t-l}{}^{gf}}{\sigma j}\right)^2\right]$$

where $U_j = (A_i, B_i C, D_i F, \sigma_j)$ gives the parameter of the model to be estimated and Ω_{t-1} is the available information at time $t-1$.

To determine whether the volatility in crude oil prices and the global factor are significant in determining regime changes, we consider a time-varying Markov switching model following Reboredo (2010). Thus, the dynamic transition probability of the matrix in the regression is specified as follows:

$$P(t) = \begin{bmatrix} P11_t & 1-P22_t \\ 1-P11_t & P22_t \end{bmatrix}$$

Here, the possibility of regime switching is time-varying given the evolution of the crude oil price changes and the dynamic global factor. In this case, the transition probability is specified as follows:

$$P11_t = \frac{\exp\{W_1 + U r_{t-1}{}^{oil} + W_1 Y_{t-1}{}^{gf}\}}{1+\exp\{W_1 + U_1 r_{t-1}{}^{oil} + W_1 Y_{t-1}{}^{gf}\}}, \text{ and } P22_t = \frac{\exp\{W_2 + U_2 r_{t-1}{}^{oil} + W_2 Y_{t-1}{}^{gf}\}}{1+\exp\{W_2 + U_2 r_{t-1}{}^{oil} + W_2 Y_{t-1}{}^{gf}\}}$$

[2] See Maheu and McCurdy (2000) and Perez-Qurous and Timmerman (2001).

The impact of the crude oil price and the global factor on the regime transition probabilities is determined by the significant value of the parameters U_1 and U_2 in addition to W_1 and W_2. Hence, sector returns are likely to stay in regime 1 when the estimated coefficient of U_1 is positive and crude oil prices are rising, whereas they are most likely to move to regime 2 when the estimated coefficient of U_1 is negative with rising crude oil prices. Even more so in the absence of crude oil impact on volatility, the parameters W_1 and W_2 give the regime transition probabilities.

4. Empirical Results

The returns of the weekly sector stock indices and crude oil are computed on a continuously compounded basis as $r_{mn} = \ln\left(\frac{P_{mn,t}}{P_{mn,t-j}}\right) * 100$, where $P_{mn,t}$ and $P_{mn,t-j}$ are the weekly closing stock price in sector m in stock market n for weekly days t and $t-j$, respectively.

Table 1. Constant Markov Switching Model

Parameters	(1)	(2)	(3)
Saudi Arabia: Regime 1			
A_1	-0.025 **(0.8790)**	0.397[x] **(0.004)**	-1.431 **(0.1461)**
B_1	0.138[x] **(0.0002)**	0.085[y] **(0.0225)**	0.176 **(0.1466)**
D_1	-0.021[y] **(0.0450)**	-0.0375[x] **(0.0009)**	-0.130[y] **(0.0232)**
σ_1	0.568[x] **(0.0000)**	0.793[x] **(0.0000)**	1.987[x] **(0.0000)**
Regime 2			
A_2	-0.070 **(0.9144)**	-0.834 **(0.2692)**	0.392[x] **(0.0058)**
B_2	0.152[z] **(0.0747)**	0.116 **(0.2507)**	0.179[x] **(0.0000)**
D_2	-0.076[y] **(0.0417)**	-0.126[y] **(0.0128)**	-0.047[x] **(0.0001)**
σ_2	1.780[x] **(0.0000)**	1.872[x] **(0.0000)**	0.830[x] **(0.0000)**

Parameters	(1)	(2)	(3)
P11	2.888^{x} **(0.0000)**	3.669^{x} **(0.0000)**	1.640^{x} **(0.0035)**
P22	-2.11^{x} **(0.0000)**	-2.238^{x} **(0.0001)**	-3.23^{x} **(0.0000)**
Log-Likelihood	-1058.534	-1059.349	-1087.392
United Arab Emirates: Regime 1			
A_1	0.190^{z} **(0.0749)**	0.191^{z} **(0.0821)**	-0.361^{x} **(0.0039)**
B_1	0.103^{x} **(0.0002)**	0.073^{x} **(0.0083)**	0.019 **(0.4607)**
D_1	-0.024^{x} **(0.0058)**	-0.000 **(0.7701)**	-0.029^{x} **(0.0035)**
σ_1	0.875^{x} **(0.0000)**	0.632^{x} **(0.0000)**	0.740^{x} **(0.0000)**
Regime 2			
A_2	0.118 **(0.7957)**	-0.091 **(0.7407)**	1.337^{y} **(0.0378)**
B_2	0.038 **(0.7818)**	0.101 **(0.2697)**	0.149 **(0.2641)**
D_2	-0.167 **(0.2215)**	-0.020 **(0.5608)**	-0.054 **(0.2724)**
σ_2	2.635^{x} **(0.0000)**	2.045^{x} **(0.0000)**	1.989^{x} **(0.0000)**
P11	3.954^{x} **(0.0000)**	2.428^{x} **(0.0000)**	2.056^{x} **(0.0000)**
P22	-1.659^{x} **(0.0001)**	-1.828^{x} **(0.0000)**	-0.696^{y} **(0.0347)**
Log-Likelihood	-1633.453	-1743.618	-1687.609
China: Regime 1			
A_1	0.270 **(0.2298)**	0.296^{z} **(0.0738)**	0.376^{y} **(0.0628)**
B_1	0.149^{y} **(0.0367)**	0.082^{y} **(0.0387)**	0.169^{x} **(0.0003)**
D_1	-0.059^{x} **(0.0061)**	-0.024^{z} **(0.0614)**	-0.032^{y} **(0.0433)**
σ_1	1.234^{x} **(0.0000)**	0.998^{x} **(0.0000)**	1.254^{x} **(0.0000)**
Regime 2			
A_2	0.166 **(0.6253)**	0.465 **(0.3244)**	-0.401 **(0.6468)**

Parameters	(1)	(2)	(3)
B_2	-0.076 **(0.4101)**	0.012 **(0.8196)**	-0.171 **(0.2490)**
D_2	-0.149[x] **(0.0008)**	-0.176[x] **(0.0000)**	-0.241[x] **(0.0003)**
σ_2	2.089[x] **(0.0000)**	1.801[x] **(0.0000)**	2.011[x] **(0.0000)**
$P11$	2.457[x] **(0.0000)**	3.450[x] **(0.0000)**	3.982[x] **(0.0000)**
$P22$	-2.054[x] **(0.0015)**	-2.642[x] **(0.0000)**	-2.824[x] **(0.0000)**
Log-Likelihood	-1761.398	-1551.855	-1648.042
India: Regime 1			
A_1	-0.280 **(0.6361)**	-0.064 **(0.6907)**	0.483[y] **(0.0341)**
B_1	0.018 **(0.8411)**	0.016 **(0.6920)**	0.171[x] **(0.0015)**
D_1	-0.269[x] **(0.0000)**	-0.036[x] **(0.0074)**	-0.055[x] **(0.0027)**
σ_1	1.942[x] **(0.0000)**	1.245[x] **(0.0000)**	.57037[x] **(0.0000)**
Regime 2			
A_2	0.480[x] **(0.004)**	-0.402 **(0.4854)**	-1.291 **(0.1597**)
B_2	0.091[y] **(0.0276)**	0.226[y] **(0.0387)**	-0.057 **(0.6815)**
D_2	-0.058[x] **(0.0000)**	-0.262[x] **(0.0000)**	-0.462[x] **(0.0000)**
σ_2	1.279[x] **(0.0000)**	2.139[x] **(0.0000)**	2.196[x] **(0.0000)**
$P11$	3.195[x] **(0.0000**	4.857[x] **(0.0000)**	4.726[x] **(0.0000)**
$P22$	-4.634[x] **(0.0000)**	-4.045[x] **(0.0000)**	-3.125[x] **(0.0000)**
Log-Likelihood	-1831.77	-1885.188	-2002.574

Note: This table gives the estimation results of the constant Markov switching model with constant regime switching parameter A_i, switching crude oil parameter D_i, switching global factor parameter D_i and switching regime volatility parameter σ_i. The brackets **( )** present the probability values for the estimated coefficients. [x] indicates significance at the 1% level, [y] indicates significance at the 5% level and [z] indicates significance at the 10% level. 1- corresponds to the banking/financial sector; 2- to the agriculture & food/consumer durables sector; and 3- to the industrial/construction sector.

In Table 1, the constant Markov Switching model for Saudi Arabia and United Arab Emirates shows that crude oil affects sector returns differently with varying significance levels in the stable regime, which coincides with regime 1. The result shows that crude oil returns are mostly significant, with positive impacts on sector returns in both Saudi Arabia and the United Arab Emirates in the stable regime, particularly for the banking/financial and food sectors in both countries. This impact is found to be positive in the industrial sector of both countries but statistically insignificant. In the recession regime, this impact is also positive for both countries but mainly significant for Saudi Arabia's banking and industrial sectors and statistically insignificant in the United Arab Emirates. This means that overall sector returns are largely unchanged during recession regimes in both countries. For both Saudi Arabia and the United Arab Emirates, the global factor is found to be significant in both regimes, with Saudi Arabia most affected. Similarly, volatility tends to be high in both stable and recession periods for Saudi Arabia and the United Arab Emirates. This leads to uncertainties about the potential spread of sector returns due to changes in crude oil price movements and the dynamic global factor. Moreover, the transition between the specified regimes for Saudi Arabia and the United Arab Emirates is found to be significant, as observed from the significant regime transition matrix coefficients with constant transition probabilities and expected durations in Table 2. Hence, we see that the Saudi Arabia agriculture and food sector and the United Arab Emirates banking sector generally have higher expected durations in stable regimes, whereas the Saudi Arabia industrial sector and the food sector in the United Arab Emirates have much longer durations in recession.

Table 2 Constant Markov Transition Probabilities and Expected Durations

	Regime 1			Regime 1		
Selected Countries	**(1)**	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
Saudi Arabia	0.889^{t}	0.975^{t}	0.838^{t}	0.980^{t}	0.904^{t}	0.962^{t}
	[8.99]	**[40.21]**	**[6.16]**	**[19.9]**	**[10.8]**	**[26.26]**
United Arab Emirate	0.981^{t}	0.919^{t}	0.887^{t}	0.840^{t}	0.861^{t}	0.667^{t}
	[53.17]	**[12.33]**	**[8.82]**	**[6.25]**	**[7.22]**	**[3.00]**
China	0.921^{t}	0.969^{t}	0.982^{t}	0.886^{t}	0.933^{t}	0.944^{t}
	[12.67]	**[32.5]**	**[54.64]**	**[8.78]**	**[15.04]**	**[17.84]**
India	0.960^{t}	0.992^{t}	0.991^{t}	0.990^{t}	0.983^{t}	0.958^{t}
	[25.40]	**[129.67]**	**[113.81]**	**[103.9]**	**[58.11]**	**[23.75]**

Note: This table gives the transition probabilities and expected durations for the constant Markov switching model. 1 represents the banking/financial sector return, 2- the agriculture & food/consumer durables sector return, and 3- the industrial/construction sector return. ^{t} indicates the constant transition probabilities with expected durations in parenthesis **[ ]** in weeks.

From the Constant Markov switching model in Table 1 with respect to China, crude oil return had a positive impact on the sector returns in regime 1 given stable economic conditions, but its effects in regime 2 were mostly negative, with depressing impacts on stock returns except for the food sector. For India, as indicated by Table 1, the crude oil return positively affects stock returns, but the effect is mostly statistically insignificant expect for the construction sector in the stable regime, whereas its impact is mostly positive in the recession regime, with the exception of the construction sector, which exhibits a negative impact in recession. Furthermore, both China and India are significantly affected by the global economic factor, with a negative impact on their sector returns. The volatility is also found to be highly significant and positive in both regimes for China and India. The regime probabilities and expected durations are reported in Table 2. Overall, the expected durations in India are the highest across the sample, with the consumer durables and industrial sectors lasting much longer in the stable regime, whereas the banking sector has the longest duration in recessions compared with the sample average. For the time-varying Markov Switching model[3], we found that crude oil price and the global economic factor proxy with the S&P 500 Volatility index, reported by the Chicago Board of Option Exchange, significantly affect the regime switching probabilities in our model in general.

5. Conclusions

In this study, we conducted sectoral examination of the dynamic effects of crude oil price movements on sector returns in Saudi Arabia, the United Arab Emirates, China and India using Markov switching models. The result from the constant Markov switching regression shows that sector returns respond differently to crude oil price movements considering the effects of global economic conditions in general. This evidence suggests that the impact of crude oil price shocks and the effects of the global factor on the sector returns examined vary in terms of magnitude and significance level in both stable and recession regimes across our sample. This evidence is also documented in Reboredo (2010). Overall, the India sector returns exhibit the most persistent duration in the specified regimes. Finally, the evidence from the time-varying Markov switching model with dynamic transitions indicated that crude oil and the global factor is significant in explaining the dynamic transitions between the identified regimes. Thus in this article, the dynamic impact of crude oil price movement for crude oil exporting and importing countries is investigated. The study documents evidence that shows that

[3] In the interest of brevity, this result is not reported because it is similar to that of the constant Markov switching model. The result is available upon request.

the impact of crude oil price changes differs for the crude oil exporting and importing countries, significantly. This is expected as the aggregate crude oil price shocks that are triggered by the dynamic global economic factor – due to the fluactutaion in the global business circle affect all stock market differently. The impact of such crude oil price shock depend on the exposure of the stock market to the fluaction in the global economy and the extent to which crude oil serves as production input in the sectoral composition of the market.

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