Dynamic impact of crude oil price shocks on equity market returns; A simple MS-EGARCH approach

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ABSTRACT

This study is motivated by the empirical association between crude oil price shocks and stock market returns as well the asymmetric and nonlinear effects of crude oil price movement with stock returns. Thus, the EGARCH model is employed to investigate the dynamic impact of crude oil price on equity returns in terms of it asymmetric and nonlinear effects.
We find a significant switching behaviour for our sample with varying impacts across the selected regimes. The result from our simple Markov-switch model is found to be more robust and significant compared to the extended model estimated with additional exogenous variable. Specifically, for our simple model the regime specific error variances are positive and significant for both the low and high volatility regimes in all the equity market studied. We also obtain a significant transition matrix parameter for all the equity markets in our sample with significant dynamic transition probabilities in both the low and high volatility regimes.

Keyword: Crude Oil Price Shocks, Asymmetric, Dynamic Impact, Markov-Switch, Transition Probabilities.

1. INTRODUCTION

A plethora of rich empirical study[1] shows that oil price shocks exerts tremendous impacts on the global levels of economic activity. The implication of these impacts is felt differently and in an unequal pattern in oil exporting and oil importing countries. An oil price increase is in general characterized as a positive phenomenon for oil exporting countries and a negative occurrence for oil importers. Several channel of transmission exist through which oil price volatility pass-through to the real economy, key of which are the demand and supply channels. The supply side shocks are rooted in the contribution of oil to production with the implication that oil price increases negatively induce declining output growth for firms. Conversely, demand side shocks are tied to the overall consequences of oil price increases for consumption by households and investment by firms. Oil price volatility also have an implication for a country foreign exchange and stock market activities opening up an indirect channel of transmissions of oil price changes on real economic activities in both exporting and importing countries. In sum, changes in oil price affect both exporting and importing countries via a multiplicity of medium channeling wealth ownership from oil consuming economies to oil producing nations and impacting their financial stability and global confidence.

[1] see, inter alia Hammoudeh and Choi, 2006; Killian and Park, 2007; Park and Ratt, 2008; Alou and Jammazi, 2009; Filis, 2010; Filis et.al, 2011; Arouri et.al, 2011; Jammazi, 2012; Wang et.al, 2013; Chang et.al, 2013; Cunado and Perez de Gracia, 2014; Dhaui and Khraref, 2014

The adverse negative effect of crude oil price movement on equity returns has received considerable attention. In spite of the claim of significant negative association, there are mix evidences on the impacts of crude oil on the aggregate economy. Jones and kaul (1996) using a quarterly data found a statically significant negative correlation for crude oil price shocks and equity returns in their sample. They also found that the real stock return for the United State (US) is affected significantly by negative shocks to crude oil prices. While this is the case, empirical evidence from Huang et.al (1996) shows that there are no significant association between crude oil future prices and equity return on aggregate whereas this is not the case for specific crude oil firms. I.e. this study found that crude oil future price has a statistically significant impact on equity returns for specific firm. Similar evidence is also documented by Sadorsky (2001).

To empirically investigates the association between crude oil price and stock market returns, the current study adopts a nonlinear methodology on the premises that the effects of crude oil price changes on equity returns is dependent on dynamic unobservable interplay in the various phases of the economy. Raymond and Rich (1996) employing a Markov-switching model had earlier observed this nonlinear correlation for crude oil price shocks and the economic cycle dynamics for the United State (US) economy. Furthermore, it was established by McQueen and Roley (1993) that equity prices reaction to aggregate economic policy news was significantly influenced by the state of the macro economy. Evidence also exist in literature which shows that equity return volatility altered significant during boom and burst economic phases such that the volatility in equity return was high in the periods of economic recession compared to its levels during economic expansion (schwert 1989; Hamilton and Lin 1996).

More so, employing a Markov-regime switch model, Chauvet and Potter (2000) as well as Perez and Timmermann (2001) observed a nonlinear pattern in the empirical relation for the equity market return in their respective sample of study.
Following the evidences from empirical literature, we adopt Hamilton (1989) Markov-switching model and like Reboredo (2008) extend the simple linear regression model by Jones and Kaul (1996). Thus, we estimated a base line EGARCH and a Markov-switching regime model to investigate the impact of the nonlinearity in crude oil price movement on equity returns and its effects.

The approach of the current study is reinforced by the empirical conclusion of nonlinear relation for the conditional distribution of equity returns that have been widely reported in many studies as well as the nonlinear association between crude oil prices and aggregate economic output. In this regards, empirical evidence found statistically significant correlation between crude oil price and aggregate output with the implication that this empirical relationship is inversely related with rising crude oil price and statistically insignificant when crude oil prices are falling(see inter alia Mork (1989; Mork et.al (1994);Lee et.al (1995); Hamilton (1996;2000); Balke et.al (2002)). More so, the dynamic movement in crude oil prices is a significant determinant of the extent of inflationary impact for the aggregate economy over the short and long time periods. This is significant as it is an indication of the directional shift in both real interest rate and equity price positions. It may also be the case that there is an overreaction or under-reaction to news about the dynamic impact of crude oil price changes for the investing public especially with imperfect information about the stock market dynamics.

According to Reboredo (2008) news on crude oil prices with positive outcome have the tendency to counterbalance negative information about price movement and the variation in the positions of stakeholder's opinion could impact price movement with deteriorating effect on prices generally. The current paper proceeds as follows. Section 2gives a thorough empirical review of literature on the correlation of crude oil price shocks and stock market returns with all the mix evidences there in. Section 3 presents the data description and covers the analysis of nonlinear impacts of crude oil price shocks on stock returns and it asymmetric effects. Section 4 presents the Markov switch model incorporating fixed transition probabilities with analysis of the effects of crude oil price for the identified regimes. Section 5 concludes the article.

2. EMPIRICAL LITERATURE

A seminal study investigating the dynamic correlation between international oil price changes and stock market is attributed to Ewing and Thompson (2007). This study investigated the correlation between oil prices and a list of important macroeconomic variable such as industrial output level, consumer-prices, unemployment levels and stock market prices. To ensure a better comprehension of the dynamic correlation in the variables under investigation, Ewing and Thompson (2007) employed three separate filtering techniques to analyze the cyclical patterns in the crude oil prices and the economic variables it set forth to examine. The study finds pro-cyclicality in oil price movement lagging industrial output level and stock market prices. Similar evidence is documented by Ebrahim et.al (2014). Specifically, they reported evidence which suggest cyclicality and seasonality in oil demand and a contemporaneous pro-cyclicality in crude oil and real industrial output.

Using a multivariate VAR methodology with both linear and nonlinear specification, Park and Ratti (2008) conducted a study to examine the effects of crude oil prices shocks and volatility on the real stock market returns for the U.S and 13other European economies for the periods from 1986:1 to 2005:12. This study concludes that shocks to crude oil price has a contemporaneous statistical significant impact on stock return for all the countries covered over the period of the investigation. Specifically, this study attempts to isolate the magnitude of this impact for oil exporting and oil importing countries in its sample of study. Hence, it found that an oil exporting country such as Norway exhibited a positive correlation in its stock market returns to crude oil price increases whereas the reverse was the case for oil importing countries in the sample. It further noted that an increase in crude oil price volatility has a depressing impact on real stock market returns in most of the European economies it covered but not so for the U.S stock market. Finally, it reported that contrary to evidence for the U.S and Norway, there is an insignificant asymmetry in the effect of real stock market return either positively or negatively on oil importing economies in Europe.

Apergis and Miller (2009) examined the pattern of structural oil market innovation for a sample of eight economies namely; Australia, Canada, France, Germany, Italy, Japan, the U.K and the U.S. Employing a modified version of Killian (2009) and a vector error correction/ vector autoregressive model disentangled the innovation in crude oil market in 3 separate components. These are supply side oil-price shocks, global aggregate demand side shock and the global oil demand side shocks. This study then examined the impact of the mentioned structural shocks on the stock return for the countries in its sample. It found evidences that suggest that crude oil market related structural innovations are significant in an attempt to explain the dynamic

movement in stock returns. Specifically, the study found that structural oil market innovations do not statistically significantly affect the stock market returns for it sample of countries.
Aloui and Jammazi (2009) employed a Markov-switching EGARCH technique credited to Henry (2009) to study the impacts of the crude oil price innovation on the dynamic behavior of stock market returns for a sample of three developed economies. These are France, the U.K and Japan. They based their justification for the Markov-switching EGARCH framework on account that it allowed then to segregate two distinct shocks to the crude oil prices considered (WTI and the European Brent). This technique allows them to alternate between a low mean and high volatility regime and to isolate any time variation and asymmetric effect in the conditional variances of the identified regimes. Thus, in this study the impact, persistency and asymmetry of innovation to stock market return volatility is crucially dependent on the regime dynamics. The overall finding of this study indicated that an increase in crude oil prices impacts the volatility of stock market returns and the transition across regimes.

Filis (2010) examined the tendency for cyclical patterns amongst the overall macro economy, stock market returns and crude oil prices for Greece. The study adopts a Co-integration and vector error correction method alongside a multivariate VAR framework for the period between1996:1 up until 2008:6. The findings from the cyclical component showed that crude oil prices and stock market return for Greece exhibits a negative correlation. Arouri and Nguyen (2010) estimated a multifactor asset pricing model to examine the correlation between crude oil price changes and sector specific stock market returns for a group of European countries. The aim of this study was to examine the cyclicality pattern and the responsiveness of the stock market returns to crude oil price swings and the European market dynamics as well their causal behavior. The result of this study reported from the in-sample investigation revealed a weak relationship between crude oil price changes and stock market returns. It also noted that the sensitivity of the stock market returns to crude oil price movements varies based on sector specific activities. It equally finds asymmetry in the association between crude oil price changes and stock market returns.

Filis et.al (2011) adopts a DCC-GARCH-GJR model to study the dynamic relationship that exist between stock market returns and crude oil prices changes for a group of oil exporting and importing countries. These groups of country include Brazil, Mexico and Canada in the oil exporting bloc while on the other hand Netherland, Germany and U.S fell in the oil importing groups of country. The result of this study indicates that the dynamic correlation is same for both oil exporting and the oil importing countries. It finds that the association is significantly positive given significant global demand side shocks to crude oil price and negatively significant in response to precautionary global demand side innovations. These shocks are attributed to either global dynamics in the business cycle or global upheaval such as wars. It found no significant association between supply side innovation for both the oil exporting and importing market. The lagged-correlation findings from this studies showed that crude oil price exerts an inverse impact in all the stock market studied with a positive impact recorded only during the financial crisis of 2008. In sum, the conclusion from this study shows that in period of significant economic down turn, the crude oil market do not guarantee immunity from stock market crash. Arouri et.al (2011) employed a generalized VARGARCH model to study the linkage between stock return and volatility pass through from world crude oil prices changes to stock market for economies in the GCC from 2005 to 2010. This study reports a statistically significant innovation and spillover of volatility between crude oil and stock market return over the sub crisis period in its sample. It also observed that an increase in volatility in crude oil prices due to policy change and innovations threatening oil supply and demand side equilibrium positively increases the volatility in the GCC stock market return. Mesih et.al (2011) examined how essential crude oil price changes and volatility are for the performance of stock markets alongside the impacts of policy measures given volatility in crude oil prices for South Korea considered as a net importer. The study was based on the VAR methodology and a bivariate Markov switching technique. The findings from this study revealed a significant influence of crude oil price volatility on real stock market returns in South Korea. Thus, this study observed that a persistently high and volatile crude oil prices exerts a tremendous negative spillover effect for the whole economy, hence a deliberate policy to minimize volatility in crude oil prices. Schubert et.al (2011) investigates the implication of oil price changes for a developing country classified as an oil importer. The goal was to examine the degree as to which crude oil price innovation is dependent on a country's domestic production system and its proximity to the global market. It found that over the long term horizon the impact of crude oil price shocks in a country is significantly determined by the very structure of the economy more than its access to the world financial market.

Arouri (2011) using a linear asymmetric model studied the sensitivity of some European stock market returns to crude oil price changes form 1998:1 to 2010:6. The study sample included Demark, Austria, Belgium, Finland, Germany, Greece, Iceland, Italy, Luxembourg, Netherland, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom. This empirical investigation showed that the magnitude of the sensitivity of European stock market returns to crude oil price variations depend significantly on the sector specific impact. More so, this study found asymmetric responses in the sensitivity of stock market returns to crude oil price changes in its sample of study. Mohanty et.al (2011) also examined the correlation between oil prices and stock market returns for the GCC economies employing a country level and industry specific stock return. The empirical result from this study indicates that at national level with the exception of Kuwait, stock market returns exhibit a statistically significant response to crude oil price shock. For the industry specific level, the empirical findings differ across the sample of industries studied. Specifically, 12 of the 20 industry covered showed a positive sensitivity to crude oil price shocks. Fayad and Daly (2011) also examined the effect of crude oil innovation on stock returns drawing a comparison between the GCC economies with the economies of US and UK. This investigation was conducted using a VAR methodology from 2005:9 to 2010:10.

Furthermore, Basher and Sadorsky (2012) recognized the significance of the association between crude oil price and stock market price on the one hand and the relationship with exchange rate on the other hand. Thus, they estimated a structural vector autoregression model to study the dynamic association between crude oil price changes, exchange rate fluctuation and stock market return for an emerging country. This study finds evidence that positive innovation to crude oil price depresses stock market prices in emerging economies. It also found evidence that a positive shock to crude oil production decreases crude oil prices whereas a positive innovation to real productivity activities stimulate a rise in crude oil prices. Overall, this study reports a positive correlation between stock market prices in an emerging economy and crude oil price changes. Jammazi (2012) on the bases of a Wavelet multivariate markov switching GARCH model investigated the transmission mechanism of crude oil price shocks to stock return for a sample of five developed economies namely; US,UK, Japan, Germany and Canada. Jammazi (2012) argued that crude oil price is driven by nonlinearity and chaotic patterns in its behavior making it challenging to model their dynamic fluctuation. This study reveals that the sensitivity of stock market returns for the countries examined to crude oil price shocks is significantly dependent on origin. It find evidence that with the exception of Japan and UK, major supply source of crude oil in terms of origins, played a key role in the sensitivity of stock market returns to crude oil price shocks. Specifically, it concludes that for crude oil importers in its sample such as Germany (Canada), increases in real oil price innovation emanating from centers outside Europe; North America (From European centers, African and middles east sources) depresses the stock market returns significantly. Conversely, crude oil price innovation emanating from Europe and Eurasia (North America) tends to be less significant.

Ghoral et.al (2012) used a combination of BKK-GARCH, CCC-GARCH and a DCC –GARCH models to study the spillover in volatility and time varying correlation between crude oil price and the stock market index return from 1997:1 to 2010:10. This study was done for a list of oil exporting and oil importing stock markets. These are Russia, Norway, Canada, Malaysia, Argentina and Venezuela. Other are US,UK, France, Belgium, Denmark, Greece, Portugal, Sweden, Germany, Switzerland, Netherland, Japan , Korea, Hong Kong, Singapore, Thailand, China, Indonesia and Brazil. The result from this investigation does not support evidence for constant correlation between crude oil prices and stock market returns. Crude oil price shock is also found to exert a positive impact on the relation between oil prices and global stock market returns in periods of financial upheaval. More so, Wang et.al (2013) using a structural VAR framework find that the extent, length and sensitivity of stock market returns to crude oil price innovation is greatly influenced by whether the country is a net oil importing or net oil exporting economy. This study also finds that the relationship depends on the significance of crude oil for the country. Furthermore, it found a more significant and persisting impact of global demand uncertainty on stock market returns for net oil exporters compared to importers. Also For the oil exporters, this study reports that global precautionary demand side shocks results in a significant dynamic movements in their stock market returns compared to net oil importers.

Based on the evidences of co movement between crude oil prices and stock market returns, Beckmann and Czudaj (2013), set forth to investigate if homogeneous correlation exists in the dynamics between crude oil prices and the currencies of oil importing and exporting countries. The countries studied include US, UK, Brazil, Canada, The Euro Area, India, Russia, Norway, Japan, Mexico, South Korea and South Africa. This study employed a Markov-switching vector error correction technique. It reports that with respect to correlation patterns, result varies across country with a significant causality from exchange rate to crude oil price. It notes that the depreciation of the US dollar leads to an increase in crude oil prices. Cunado and Perz de Gracia (2014) focusing specifically on a set of European countries studied the effects of crude oil price innovations on stock returns for 12 importing countries. These are UK,Germany, France, Finland, Denmark, Belgium, Austria, Netherland, Luxembourg, Spain and Portugal. This investigation covered the periods from 1973:2 to 2011:12 using VAR/VECM. This study finds that the sensitivity of real stock market return in Europe to crude oil price shocks varies in relation to the main trigger of the oil price change. This study further reveals the presence of a significant inverse effect of crude oil price for most of the real stock returns in the sample and found crude oil supply side shocks as significant driver of stock market returns in Europe.

Finally, Guesmi (2014) focused mainly on export oriented emerging economies to examine the dynamism in volatility spillover between crude oil price and stock market returns. The countries studied include United Arab Emirate, Kuwait, Saudi Arabia and Venezuela. This study employed the multivariate GARCH-DCC model. It finds a significant spillover in volatility and dynamic correlation between the variable studied and reports that they are significantly influenced by global conditions. This study also noted that the association between crude oil prices and stock market returns is significantly affected by the source of the crude oil shock. It found a significant sensitivity for the stock market return in it sample to shocks triggered by demand side innovation either as a result of political crisis or swings in the global business cycle contrary to production cut associated with supply side innovation.

For the current study, we employed a Markov-switching model to examine the effects of crude oil price shocks for our sample of study consisting of a list of international stock indices. The goal is to examine if the effect of crude oil price shocks for our sample of study is dependent on the states of the economy and the transition probabilities of this effects in the identified state of the economy as the case may be.

3. DATA AND METHODOLOGY

3.1Data

This study is based on a sample of global stock indices to examine the impact of crude oil price shocks on stock returns. Following Rebordo (2008) and Jammazi and Nguyen(2015), this sample is drawn from a monthly data for the CAC40 index of France, the United Kingdom FTSE 100, Japan Nikkei 225 index, SHZCOMP for China and KOSPI for South-Korea. For each of the mentioned index, the stock return is calculated by taking the first differences of the logarithmic equity prices respectively. The Brent crude oil spot and future prices are utilized as measures of the crude oil price. The crude oil returns is calculated as the equity return series for the estimation periods. For the sake of clarity, we focused on the estimated result for the Brent spot prices is the light of the co-movement in crude oil prices. The sample estimation period covers the periods of 1993M01 to 2015M08. All data used for this study is retrieved from DataStream. The descriptive statistics is presented in table 1.

Table1: Descriptive Statistics

	BRENT FUTURES	BRENT SPOT	DKORCOMP	DCHZCOMP	DJAPDOWA	DFTSE	DCAC
Mean	0.3746	0.3733	0.4005	0.7902	0.0716	0.3152	0.0374
Sd	9.2645	10.3363	7.8600	10.4249	6.0979	4.3093	5.6773
Max	27.7201	29.3032	37.9887	32.4196	19.0835	14.7228	16.4805
Min	-38.2309	-38.6900	-29.9307	-37.1110	-24.3174	-17.0375	-18.2182
Skewness	-0.4735	-0.3911	0.1313	-0.07376	-0.1832	-0.5478	-0.4063
Kurtosis	4.2159	3.7576	6.4298	4.2402	3.6680	4.7748	3.4993
JB	26.8194*** (0.0000)	13.3903*** (0.0012)	133.6087*** (0.0000)	17.6138*** (0.0002)	6.5543** (0.0377)	49.1162*** (0.000)	10.2694* (0.0059)
Q10	11.266 (0.337)	5.8560 (0.827)	17.2735 (0.0685)	11.9868 (0.2860)	14.7658 (0.1408)	11.3786 (0.3288)	10.2211 (0.4213)
ADF	-14.252*** (0.0000)	-15.837*** (0.0000)	-13.367*** (0.0000)	-16.201*** (0.0000)	-14.937*** (0.0000)	-16.298*** (0.0000)	-15.526*** (0.0000)

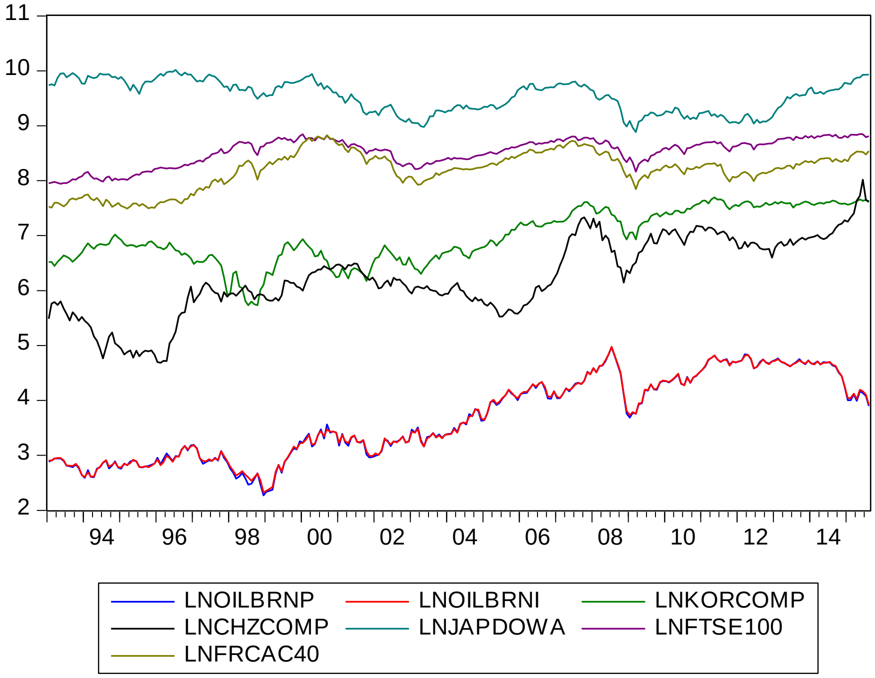
PP	-14.255*** (0.0000)	-15.837*** (0.0000)	-13.251** (0.0000)	-16.376*** (0.000)	-14.967*** (0.0000)	-16.297*** (0.0000)	-15.541*** (0.0000)
KPSS	0.0890	0.0878	0.4150	0.0400	0.0750	0.0726	0.0799

Note: ***Indicate significant at 1% level and ** indicate significant at 5% level

From the table, the average returns for the daily crude oil prices for both Brent spot and Brent Futures is positive over the sample estimation period. This is attributed to the rise in crude oil prices marking the beginning of the commodity supercycle that began in late 90s due to rising demands in emerging economies (Breitenfellner and Cuaresma, 2008; Baffes et.al 2015). The scenario is ascribed to quick recovery from the Asian financial crisis and diminished supply of crude oil around the same period due to low prices in the early 90's affecting investment in oil explorations (Breitenfellner and Cuaresma, 2008).

Both crude oil series also exhibit leptokurtosis in their behaviour as shown by the kurtosis coefficient which is statistically significant and positive. This implies that the crude oil distribution have fat and thick tails than that implied by the Gaussian distribution. The Jarque-Bera statistic further shows that the null hypothesis for normality is rejected at 1 percent level of significance meaning that the crude oil distribution are not normally distributed. The Augmented Dickey-Fuller statistic (ADF) and Phillips-Perron (PP) statistic for trend and intercept terms are indication that the null hypothesis of unit root is rejected for both measure of the Brent crude oil prices at one percent level of significance and the KPSS statistics confirms the stationarity of the series. The rest of the return series also exhibits leptokurtic behaviour as revealed by the kurtosis coefficient in all case which is significantly positive with the implication that the distribution is non-normally distributed with large and thick tails. Furthermore, the significant Jarque-Bera statistics in all cases at 1% significance level confirms the rejection of the null hypothesis of normality for all the return series and ADF and PP statistics shows that the series are all stationary while KPSS statistics reaffirms the stationarity of the series. Finally, the Ljung-Box statistic for series correlation at lag 10 (Q10) confirms the absence of series correlation in our sample.

Fig.1Natural Logarithm of the various price series



3.2 METHODOLOGY

In this study, we begin our estimation with the Exponential Generalized Autoregressive Model (EGARCH) model of Nelson (1991). This is line with the empirical model of Jammazi and Nguyen (2015). The EGARCH specification allows us to circumvent the shortcoming of the standard GARCH model in terms of imposing a non-negative constraint on the estimated parameters of the model. It should be the case that in the standard GARCH model, the estimated coefficients of both the ARCH and GARCH autogressive terms are positive and not greater than one to achieve mean reversion and conditional heteroskedaticity in the model (Brooks, 2008). This is imperative to yield a positive conditional variance in the model. However, for higher GARCH model, the positivity condition may be breached (Malmaten, 2004). The EGARCH model helps mitigates this flaw of the GARCH model and it also captures the asymmetries in the conditional variance (volatility) in response to the dynamic impact of innovation (shocks) to the system.

The EGARCH Model

$$\ln(h_t) = \varphi_0 + \omega\left[\left|\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right| - \sqrt{2/\pi} + \beta\ln(h_{t-1})\right] + \gamma\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} \qquad (1)$$

The positive conditional variance is denoted by h_t where ε_t denotes the residual term generated via the estimation of the conditional mean process.

Table2.ARMA-EGARCH Estimation result without Crude oil Price Effects

	DKORCOMP	DCHZCOMP	DJAPDOWA	DFTSE	DCAC
α	0.1611 (0.3953)	0.8257*** (4.1961)	0.4317 (0.7764)	0.3800 (1.4713)	0.5407* (1.8793)
θ_1	-1.4105*** (-8.9299)	0.9647*** (75.9338)	0.2608*** (2.8158)	-0.3266*** (-9.7037)	0.5709*** (26.6362)
θ_2	-0.6072*** (-4.2586)		0.7021*** (7.3477)	-0.9492*** (-33.2816)	-0.9127*** (-39.9395)
ϑ_1	1.6118*** (13.9966)	-0.9964*** (-294.9936)	-0.1896** (7.7384)	0.34949*** (12.3178)	-0.6053*** (-55.9602)
ϑ_2	0.7781*** (7.3249)		-0.8429*** (-9.7167)	0.9728*** (40.2280)	0.9765*** (112.9632)
φ	-0.1075 (-1.0982)	0.2248 (0.9400)	1.1867** (2.0099)	0.3366* (1.624087)	0.3124 (1.2775)
ω	0.2863*** (3.1265)	0.3682*** (3.0474)	0.0884 (0.7085)	0.2885** (2.5346)	0.4453*** (2.6924)
γ	-0.1434*** (-3.1900)	0.0253 (0.4905)	-0.2486*** (-3.0676)	-0.2177*** (-2.9789)	-0.2653*** (-3.1532)
β	0.9680*** (47.2557)	0.8872*** (14.2679)	0.6411*** (3.9954)	0.7922*** (9.5771)	0.7906*** (9.9088)
Log Likelihood	-879.4521	-992.1692	-848.4777	-744.3986	-813.5282
Q10	3.6158 (0.729)	14.332 (0.772)	8.3884 (0.211)	2.6054 (0.856)	5.8973 (0.435)
$Q^2 10$	18.069 (0.754)	5.6285 (0.854)	5.8872 (0.825)	9.0271 (0.530)	20.180 (0.728)

Notes; α denotes the constant term in the condition mean equation, θ_1 and θ_2 gives the AR term while ϑ_1 and ϑ_2 are the MA terms respectively. φ gives the constant term in the EGARCH model (Conditional Volatility Model) while ω gives the ARCH term, β gives the GARCH term and γ represent the asymmetric effect term. z statistics in shown parenthesis for the ARMA-EGARCH estimation. Q and Q^2 denotes the Ljung-Box statistics for autocorrelation for the standardized residual and standardized squared residual with probabilities in parenthesis.
***denotes significant at 1percent level, ** denotes significant at 5 percent level and * denotes significant at 10 percent level

This study adopts a Markov-switch model to analyze the association between crude oil price and stock market returns for our sample. This is following the evidence of a nonlinear association between crude oil and equity returns found in Reboredo (2008) and the possibility of a spurious relation in the basic GARCH model in the event of unobserved structural-breaks (Lamoureux and Lastrapes, 1990) leading to a significantly high persistence in the GARCH model. This follows the empirical findings from Hamilton and Susmel (1994) to capture the impacts of volatility persistency, asymmetric relation and regime dynamics in our sample in line with the stylized facts of financial asset returns. Like Jammazi and Nguyen (2015), this study adopt the empirical model of Henry (2009) model, a Markov switch Exponential Generalized Autoregressive Model (MS-EGARCH) in the estimation process.

The MS-EGARCH Model

Consider a time varying univariate MS-EGARCH model specification as follows;

$r_t = \mu_{it} + \varepsilon_t$ and $\varepsilon_{t-1}/_{I_{t-1}} \sim s_t(0, h_{it})$

$$\ln(h_{it}) = \varphi_i + \omega_i \left[\left| \frac{\varepsilon_{t-1}}{\sqrt{h_{it-1}}} \right| - \sqrt{2/\pi} + \beta_i \ln(h_{it-1}) \right] + \gamma_i \frac{\varepsilon_{t-1}}{\sqrt{h_{it-1}}} \qquad (2)$$

With I_{t-1} denoting all available information up until time $t-1$and the residual term[2] is given by ε_t. The state dependency[3] of the conditional mean in the return generation process is captured by μ_{it}. γ denotes the asymmetric term which gives the sensitivity of the conditional-volatility to news impact either good or bad. We expect a priori that a negative shock will trigger more effects on returns (i.e. the unexpected return, ε_t) compared to a positive shock same in impact size.

Following the evidence from literature such as Reboredo (2008); Jammazi and Nguyen (2015), and in line with Maheu and McCurdy (2000) and Perez-Quiros and Timmerman (2000) we specify two distinct states (i) in our model based on a non-observable discreet latent variable denoted as s_t which assumes the value zero (0) given low expectation and high variation in returns in the market denoting bearish market movement and a value of one (1) with higher expectation and low variations in returns culminating in a bullish market regime. This is consistent with empirical literatures as in Chen and Shen (2007), Li (2007), Reboredo (2008); Chen (2009); Henry (2009) and Jammazi and Nguyen (2015).

As with Hamilton (1989), we specify a first order dynamic state (two states) Markov process to describe the transition between the regimes as given below;

$p(s_t = 0 / s_{t-1} = 0) = p^{00}$

$p(s_t = 0 / s_{t-1} = 1) = 1 - p^{11}$

$p(s_t = 1 / s_{t-1} = 0) = 1 - p^{00}$

$p(s_t = 1 / s_{t-1} = 1) = p^{11}$

The dynamic probability that the equity market alternates between regimes $t-1$ to t is given by $p(s_t = i / s_{t-1} = i) = p^{ii}$, for *i=0,1* satisfying the condition that $p^{i1} + p^{i2} = 1$. Furthermore the time path of the expected dynamic states i is denoted by *E(D)= 1/(1-p)*. In line with the deductions from Henry (2009) and Jammazi and Nguyen (2015), we assume a constant transition probability over the estimation period denoted by a logistic relation of the form $p^{00} = \frac{e(\theta_0)}{1+e(\theta_0)}$ and $p^{11} = \frac{e(\theta_0)}{1+e(\theta_0)}$.

With the foregoing methodological construct, we carefully estimated two distinct and separate models to examine the dynamic impact of crude oil price shocks for the equity market returns of our sample of study. The first model is an ARMA-EGARCH model without crude oil price effects for the selected stock markets under study. This is to serve as our baseline model as in Jammazi and Nguyen (2015) to ascertain the reaction of conditional volatility to the equity market shocks and its persistence. But unlike Jammazi and Nguyen (2015), the baseline model is devoid of regime dependency. This is based on an extended construct from Reboredo (2008) where in a simple regression model proposed by Jones and Kaul (1996) was utilized as a baseline model

[2] This follows a student's t-distribution. See Bollerslev (1987).

[3] See note on the validity of this in Jammazi and Nguyen (2015).

without regime dynamics to describe the nonlinear relations between crude oil and equity returns. The baseline model is then extended by the addition of additional aggressors with regime dynamics to examine the regime changes in our model and its impacts. Thus, based on the factor model of return[4] in Reboredo (2008), we considered the addition of an industrial production index variable (growth rate) and the consumer price index as proxy for inflation variable. The additional regressors were computed as the first differences of the logarithm of the variables[5] and included as non-switching regressors during the estimation. Finally, the regime smoothed probabilities are obtain as an upshot of our estimation process based on information from our whole sample helping us to ascertain the occurrence and tendencies of the regime dynamics.

Table3: The Markov-Switch Model Result with Crude oil price Impact and Additional Regressors

	DKORCOMP	DCHZCOMP	DJAPDOWA	DFTSE	DCAC
β^0	-0.3892 (-0.3377)	-0.1230 (-0.2850)	-0.6180 (-0.8177)	-0.6350 (-1.1027)	-6.1685*** (-4.2923)
β^1	0.7297** (2.0058)	2.4075 (1.4404)	1.7018** (2.1422)	1.1191*** (4.9420)	0.7693** (2.4223)
β_0	0.2612** (2.7605)	0.0403 (0.6423)	0.2108*** (4.1005)	0.1220** (2.7480)	- 0.805677** (-5.0065)
β_1	0.0983** (2.0058)	0.1238 (0.6423)	-0.0458 (-0.8154)	0.0417* (1.6265)	0.1599*** (5.2549)
σ_0	2.4428*** (28.9977)	1.9443*** (26.1894)	1.8452*** (32.2105)	1.7065*** (21.1787)	1.5631*** (8.0887)
σ_1	1.5436*** (27.0757)	2.6755*** (28.0183)	1.234893*** (4.382007)	0.7844*** (8.4395)	1.5573*** (31.5470)
p^{00}	3.5097*** (5.2170)	3.4335*** (5.2364)	2.9364*** (3.2464)	2.2193*** (3.6071)	0.5687 (0.3467)
p^{11}	-4.5181*** (-6.0123)	-3.0168*** (-3.5093)	-1.8927*** (-2.6887)	-2.4057 (-4.7077)	-3.4986*** (-6.5790)
Log Likelihood	-891.7765	-997.2270	-858.0606	-743.4267	-831.8203
γ^0	-0.2200 (-0.1600)	-0.1686 (0.1115)	1.6794 (8.9828)	-0.5829 (-0.9837)	1.1362** (2.3933)
γ^1	0.8010* (1.8081)	2.0262 (1.1463)	-0.1339 (-0.3272)	1.2057*** (4.7322)	-1.8968 (-1.2569)
γ_0	0.2391** (2.5148)	0.0262 (0.3253)	0.2543*** (13.6274)	0.1238** (2.7456)	0.1275** (2.5576)
γ_1	0.1094** (2.5400)	0.0833 (0.5131)	0.1277*** (3.4380)	0.0458* (1.7497)	0.0402 (0.3381)
σ_{11}	2.4293*** (28.7044)	1.9133*** (20.6705)	-0.8091*** (-2.6048)	1.7069*** (21.2526)	1.4465*** (18.4539)
σ_{00}	1.5341*** (26.5745)	2.6509 (26.1393)	1.7921 (39.0979)	0.7782*** (8.6466)	2.0740*** (15.9422)
g^{00}	3.5138***	3.4940***	0.1969	2.2051***	3.2328***

[4] The idea is derived from standard cash flow dividend model attributed to separately to Campbell and Shiller (1988) and Campbell (1991) in explaining the variation of stock returns over time.

[5] The choice of the variable is based on the theoretical construct of Jones and Kaul(1996)

	(5.2054)	(4.2477)	(0.2991)	(3.6818)	(5.6422)
g^{11}	-4.5204*** (-5.9933)	-3.2113*** (-3.0556)	-3.4908*** (39.0979)	-2.400 (-4.8373)	-1.9485 (-2.7609)
Inf	-1.0504 (-1.1766)	0.3958 (0.3057)	1.6536*** (3.0360)	-0.450045 (-0.772396)	-0.9593 (0.6877)
IP	0.3439** (2.0775)	0.2693 (1.4607)	0.2131*** (4.0126)	0.1811 (0.7273)	0.2800 (1.0851)
Log Likelihood	-888.7815	-931.2760	-854.8943	-742.7681	-833.7313

Note: Z statistics in parenthesis. β^0 β^0 $(\gamma^0\gamma^0)$ are the constant terms, $\beta_0\beta_1$ $(\gamma_1\gamma_0)$, $\sigma_0\sigma_1$ $(\sigma_{00}\sigma_{11})$ are the regime switching parameters and p^{00} p^{00} $(g^{00}g^{11})$ are the transition matrix parameters

Markov Transition Probabilities and Expected Durations

	DKORCOMP	DCHZCOMP	DJAPDOWA	DFTSE	DCAC
q^{00}	0.9710 (34.4393)	0.9687 (31.9850)	0.9496 (19.8476)	0.9020 (10.2011)	0.9620 (26.3511)
q^{11}	0.9892 (92.6676)	0.9533 (21.4253)	0.8691 (7.6374)	0.9173 (12.0880)	0.8753 (8.018455)

Note: Expected duration in parenthesis.

4.0 EMPIRICAL RESULT PRESENTATION

The empirical result presentation begins with the ARMA-EGARCH model without Crude oil Price Effects which is set as the baseline model for our estimation. Our goal is to provide additional evidences on the motion that the effects of crude oil price shocks for equity market is based on dynamic unobserved occurrences in an economy. This view was investigated by Roberedo (1988) motivated by the empirical nonlinear association between crude oil and stock market movements. We begin our analysis with a descriptive statistics table of our variables of interest. These are the Brent crude oil spot and future prices as well as the stock market returns for South Korea, China, Japan, The United Kingdom and France. In the light of the co movement amongst crude oil prices opined by Bentzen (2007), our estimation result is based on the crude oil spot price for the sake of clarity and brevity.

A cursory glance at Table 2 immediately shows that all the ARMA terms in the equation for the conditional mean are very significant and are without serial correlations. The estimated results from the EGARCH model (conditional volatility model) shows that conditional volatility is very sensitive to market shocks in all the stock market studied expect for Japan. For Instance, Apergis and Miller (2009) had reported the absence of causality for the Japanese stock market following shocks to crude oil price. Furthermore, we find that the stock market studied showed a significant level of persistency in conditional volatility with South-Korea showing an exceptional long duration in volatility persistency. Mashi et.al (2007) had argued that South Korea was one of the major countries hit most by the Asian Financial crisis with depressing impact on the equity market. More so, we found a significant asymmetric effect in all stock market studied except for China. This is line with the stylized facts of financial market series. Thus empirical evidence indicates that volatility of equity market returns tends to increase significantly in recessions compared to period of economic boom (Schwert, 1989 and Hamilton and Lin 1996). In this regards, the evidence of nonlinear effects in the conditional distribution of stock market returns (Reboredo, 2008) is upheld for our sample of study with China as an exception.

Table3 presents the result of the Markov-Switch model with crude oil price impact and additional regressors. This is motivated by the evidence of nonlinearity and asymmetric effect for the equity markets listed in our sample of study in line with the widely documented evidence of asymmetric time varying-volatility reported by empirical studies on stock markets (Wang et .al, 2015). Before presenting the result of the regime switching, we documented the estimated result from two separate models with switching regimes. For the first model, the simple Markov-switch model, our estimation was implemented without the inclusion of the industrial production index and inflation variable (consumer price index) while the second model includes the additional regressors. Both models were estimated allowing regime specific error variances and a constant term. This is based on the model proposed by Hamilton (1989), although allowing the intercept term with regime specific variances to be dependent on the regimes as in Reboredo (2008).
Our switching model specified two distinct states of the economy with varying impact of crude oil price shock for the sample equity market returns classified as low volatility and high expected returns regime on the one hand and high volatility, low expected returns regime on the other. Thus, we represent the low volatility regime with the value of 0 and the high volatility regime with 1. Starting with Simple Markov-switch model we find that crude oil price shocks had significant and positive impacts for KORCOMP, JAPDOWA (Nikkei 225) and FTSE 100 while it had a significantly negative effect on the CAC 40 stock returns in the low volatility regime. Meaning that for the low volatility regime, negative crude oil shock would tend to depress the CAC 40 equity returns significantly than positive stocks of same magnitude. While positive shocks to crude oil price do not adversely impact equity returns for KORCOMP, JAPDOWA and FTSE 100. Furthermore, we found an insignificant effect of crude oil price shocks to equity returns for CHZCOMP in the low volatility regime. For the high volatility regime, crude oil price shock is found to be positive and significant for the equity returns in KORCOMP, FTSE 100 and CAC 40 and insignificant for CHZCOMP and JAPDOWA. Thus being positively significant in both the low volatility and high volatility regime for KORCOMP and FTSE 100 with significantly positive impact in the low regime for JAPDOWA, we found that crude oil price impact on equity returns is a function of the dynamic state of the market economy. Like Reboredo (2008), we might add that it is dependent on unforeseen occurrences in the alternating states of the economy. For the simple Markov-switch model, the regime specific error variances are positive and significant for both the low and high volatility regimes in all the equity market studied. We also obtain a significant transition matrix parameter for all the equity markets in our sample with significant dynamic transition probabilities in both the low and high volatility regimes. Our result shows that the transition probabilities are positive and significant for both the low and high volatility regimes with varying expected durations. Thus, the expected duration for the equity market in low volatility regime are 34.4 months, 32 months, 19.8 months, 10.2 months and 26.4 months for KORCOMP, CHZCOMP, JAPDOWA, FTSE100 and CAC40 indexes. For the high volatility regimes KORCOMP shows the significant persistence with about 92.7 months expected duration followed by CHZCOMP with about 21.4 months, FTSE 100- 12.04 months, CAC40-8.02 months and JAPDOWA- 7.64 months. This result shows in general that with the exception of the expected duration for KORCOMP in the high volatility regime, the expected duration for the low volatility regime is more persistent. This is because the low volatility regime is associated with high expected returns and the high volatility regime is synonymous with low expected returns (Jammazi and Nguyen, 2015).

For our extended model, we observed that the log-likelihood ratio for the equity returns of KORCOMP, CHZCOMP, JAPDOWA and FTSE100 are smaller in comparison to those of the simple Markov-switch model. Thus in line with the objective of forming a parsimonious model capable of describing all the empirical feature of the data in our sample with as few parameter as possible (Brooks, 2008). We consider the result of our simple Markov-switch model more robust for all the equity market studied except for CAC40.Although in the case of the CAC40, the addition of the additional regressors (industrial production index and inflation variable) did not significantly maximize the log likelihood value as is the case in Table 3. Rather, we observed that though the coefficients of the additional variables are positive in all cases, they are not statistically significant in the case of CAC40, KORCOMP, CHZCOMP and FTSE100.
The inclusion of the additional regressors was initially motivated by the desire to investigate the asymmetric and nonlinearity observed in all the equity market returns utilized in this study with the exception of CHZCOMP returns over the period of our investigation using the EGACRH model. Thus, considering the cash flow model of Campbell and Shiller (1988) and Campbell, (1991), we conclude that the significant asymmetric effect and nonlinearity reported in our baseline model, the EGARCH model remains significant.

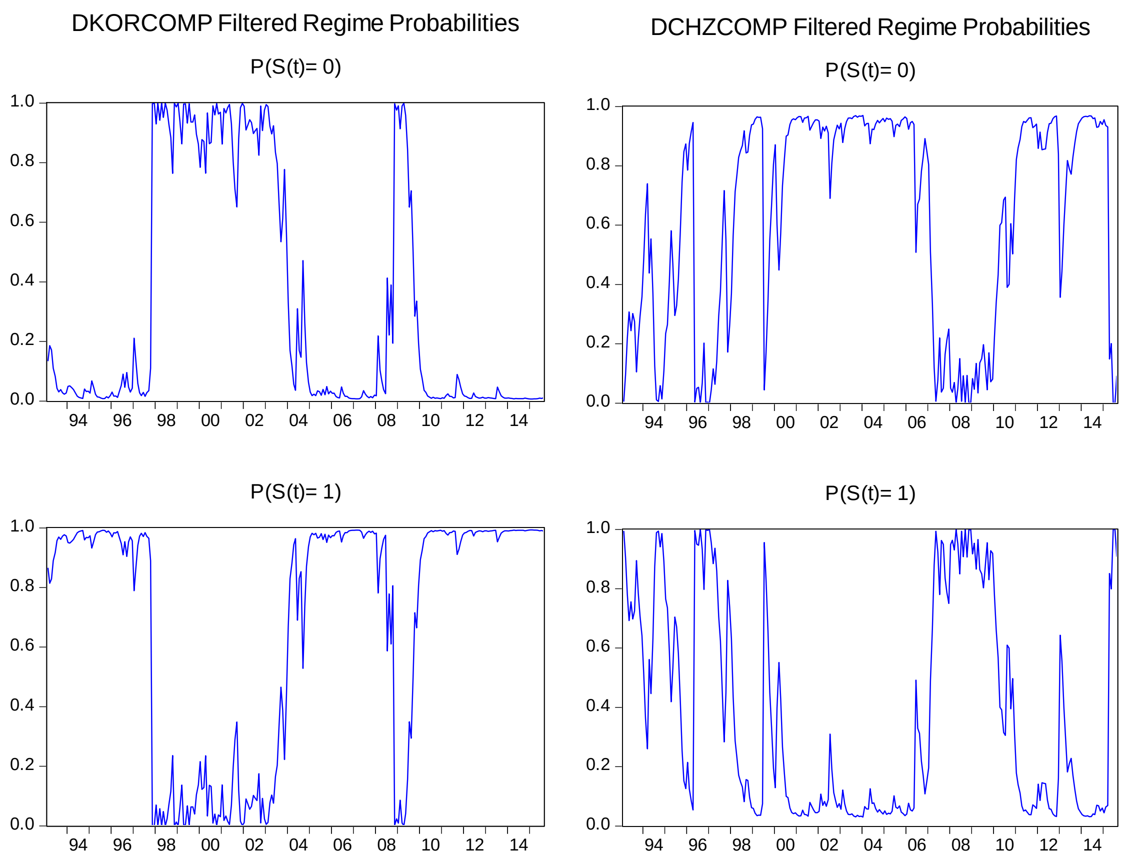


Fig.2 Filtered Regime Probabilities

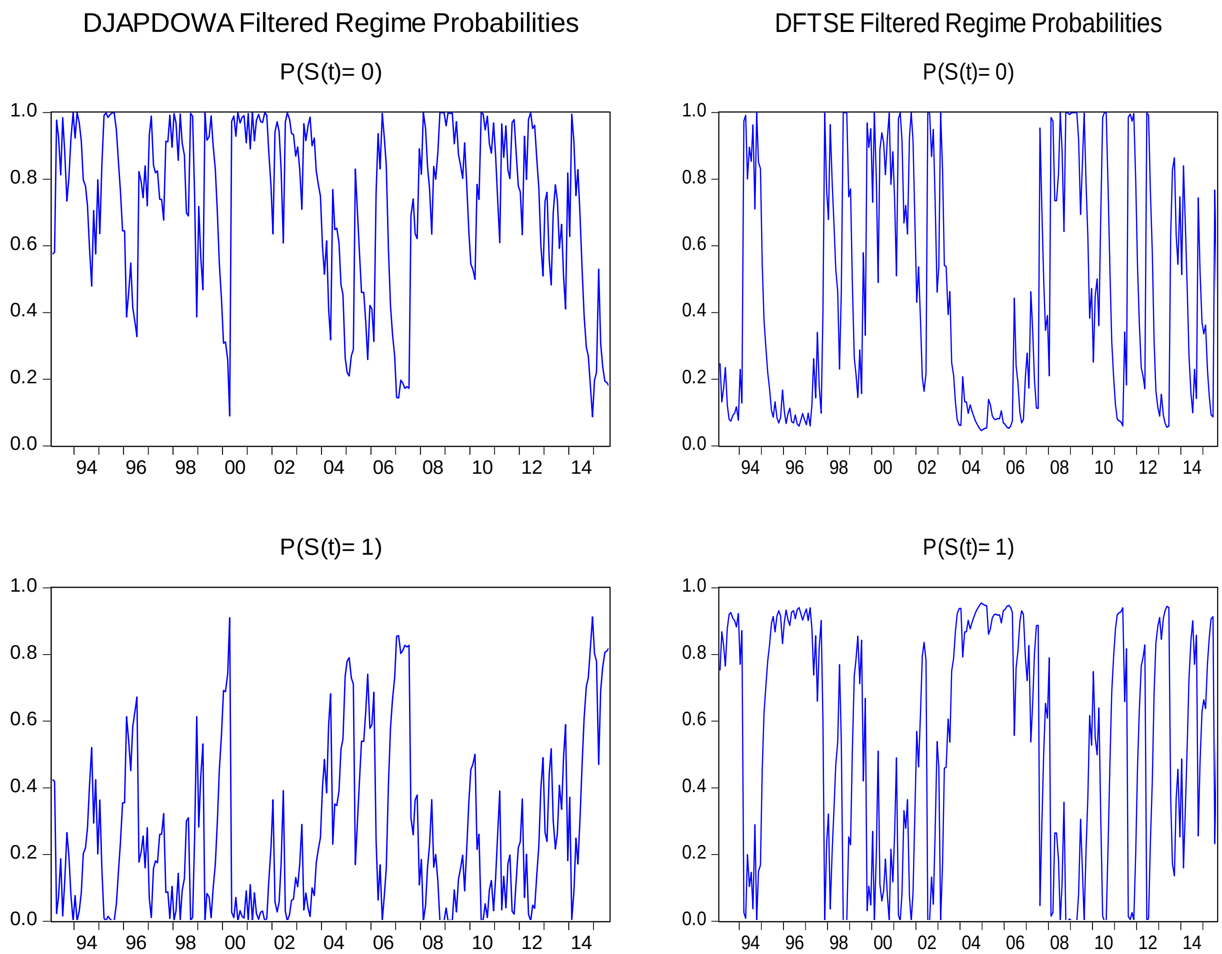


Fig.2 Filtered Regime Probabilities (cont)

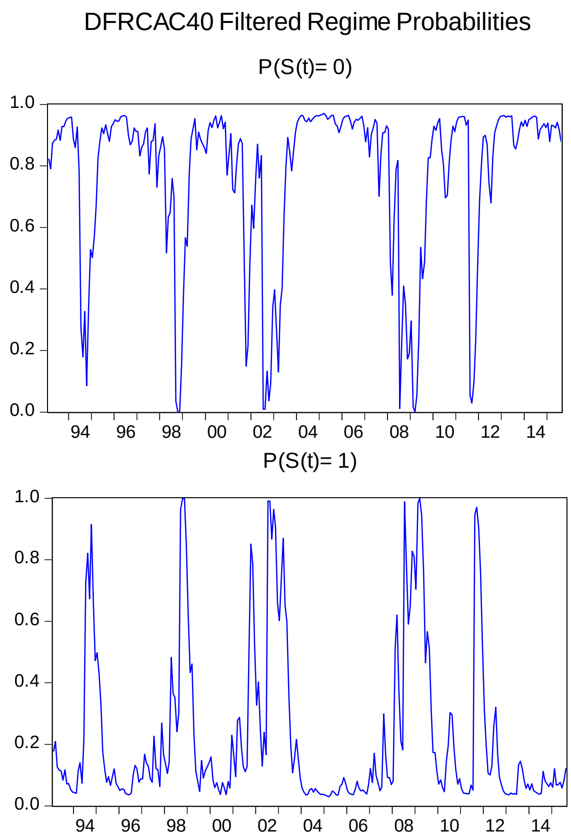


Fig.2 Filtered Regime Probabilities (cont.)

5.0 Conclusion

This study was motivated by the empirical association between crude oil price shocks and stock market returns as well the asymmetric and nonlinear effects of crude oil price movement for stock returns. In this regards, we employed the EGARCH model to investigate the dynamic impact of crude oil price on equity returns in terms of it asymmetric and nonlinear effects. This idea is based on the empirical study of Reboredo (2008) which clearly established the nonlinear impact of crude oil prices on equity return based on Jones and Kaul (1996) simple linearity model with subsequent extension of the model. We then employed the Markov-switch model and found evidences that crude oil price shock has significantly dynamic impacts for various equity markets with a magnitude and persistence that vary overtime. The evidence in this current study shows overwhelmingly that the expected duration of crude oil price shocks for low volatility regime are significantly more persistent than for the high volatility regimes.

The validity of the nonlinear evidence in our study reaffirms the often reported position that high crude oil prices are not good for equity returns in some state of the economy and good in certain other state of the economy. For instance McQueen and Roley (1993) had maintained a positive effect of economic policy news on the dynamic state of the aggregate economy in their study. This further shows the empirical nonlinear effects of crude oil price shocks on aggregate output. This is also in line with the evidence from Raymond and Rich (1996) where in a nonlinear relationship is found for crude oil price shocks and the business cycle for the United State.

Furthermore, our Markov-switch model with constant transition probabilities equally submits that crude oil price movement and crude oil price shocks do not significantly explain the transition of the regimes specified in the current study. This is also upheld in the dynamic time varying Markov-switch model of Reboredo (2008).
Finally, this study captures the essential stylized facts of equity market and crude oil returns series of nonlinearity, persistency, asymmetry and dynamic time variation.

In view of the dynamic impact of crude oil price movement given the alternating state of the economy, this study recommends timely and adequate information to mitigate either an overreaction or under reaction to the impact of crude oil price changes on stock returns by the investing public.

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