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REGIME-SWITCHING IN THE IMPACT OF OIL PRICE SHOCKS ON STOCK MARKET VOLATILITY: EVIDENCE FROM OIL-IMPORTING AND OIL-EXPORTING COUNTRIES

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ABSTRACT

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Research has highlighted the adequacy of Markov regime-switching model to address dynamic behavior in long term stock market movements. Employing a purposed Extended regime-switching GARCH(1,1) model, this thesis further investigates the regime dependent nonlinear relationship between changes in oil price and stock market volatility in Saudi Arabia, Norway and Singapore for the period of 2001-2014. Market selection is prioritized to national dependency on oil export or import, which also rationalizes the fitness of implied bivariate volatility model.

Among two regimes identified by the mean model, high stock market return-low volatility regime reflects the stable economic growth periods. The other regime characterized by low stock market return-high volatility coincides with episodes of recession and downturn. Moreover, results of volatility model provide the evidence that shocks in stock markets are less persistent during the high volatility regime. While accelerated oil price rises the stock market volatility during recessions, it reduces the stock market risk during normal growth periods in Singapore. In contrast, oil price showed no significant notable impact on stock market volatility of target oil-exporting countries in either of the volatility regime. In light to these results, international investors and policy makers could benefit the risk management in relation to oil price fluctuation.

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Kishmat Sapkota

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1. INTRODUCTION

1.1. Background of the Study

Along with the development of automation, crude oil has been the most important source of fuel in the world (International Energy Agency, 2008, page 124) and is actively traded commodity. Crude oil is an output for oil producers and exporters though it is an input factor in production process globally. Moreover, any systematic news related to oil price is likely to affect the global economy. Previous studies (for instance, Hamilton, 1996, 2011b) have found empirical evidence on influence of oil price changes on real economic activity including inflation rates and Goss Domestic Product[1] (GDP here onwards). Furthermore, Cunado and Gracia (2014) argue oil price impact is not just limited to real economic activities but also extended to financial markets. Under the assumption of efficient market and rational expectations, asset prices (hence stock prices) should depend on exposures to state variables that describe the economy (Chen et al., 1983). Stock prices are exposed to systematic economic news and the price is affected to the degree of exposure. Accordingly, the effect of oil price changes as unanticipated inflation on stock price is a general economic phenomenon in efficient markets. Often literature refer such inflation to affect the future profitability of the firms, the interest rate and ultimately stock prices. Ideally, expected future profitability of the firm is best incorporated in the stock values. As oil price shocks affect the expected net profitability of the firm, it should be addressed fairly quickly into stock prices (Jones et al., 2004). Nandha and Faff (2008) elaborate the concept that 'higher oil prices might affect the global economy through a variety of channels, which include transfer of wealth from oil consumers to oil producers, rise in production costs and impact on inflation, consumer confidence and financial markets'. Literature emphasizing the importance of oil price for economies (for instance, Arouri et al., 2012; Jouini, 2013; Papapetrou, 2001; Park and Ratti, 2008; Sadorsky, 1999; Wang et al., 2013; among others) have shed a seed of valid economic relationship between stock market return and oil price shocks.

Empirical researches on the role of changing oil prices on stock market risk seems shadowed behind. Nevertheless, a few of the studies (for instance, Marquering and Verbeek, 2004) stressing the stock market return infection by oil price changes have been found to address the volatility infection theoretically. Recently, Narayan and Sharma

[1] World Bank defines Gross Domestic Product (GDP) as the value of all final goods and services produced in a country in one year.

(2014) have pioneered the empirical research on the aspect of oil price changes impact on stock return volatility of NYSE listed firms within a single economic-regime scenario. Their result suggests a significant association of stock return volatility to oil price shocks. Through their inspiration, this thesis aims to investigate the impact of oil price changes on stock market volatility of oil-importing and oil-exporting countries in two economic-regimes scenario through a rigorous empirical research. Additionally, market selection for the analysis is based on country's higher level of dependency[2] on net oil-export and net oil-import. Finally, Saudi Arabia and Singapore are chosen as target markets[3] for the analysis as oil-exporting and oil-importing countries.

Secondly, time varying observable trends in the behavior of stock market innovations (return and volatility) could be worth considering on establishing the economic relationships. The return and risk on investments during the period of recessions are clearly distinct than that during the stable growth periods. Many economic time series make a dramatic breaks in their behavior associated with events such as financial crises or sudden changes in government policies (Hamilton and Susmel, 1994). During the unstable economic environment stock prices have followed the continuous negative returns and high volatility (see Walid et al., 2011, page 272). High possibility of loss in stock traders confidence and frequent changes in monetary policies during the unstable economic periods would reduce the market efficiency. Such instabilities during economic recessions are keen to affect the consistency in macro-economic relationships. Accordingly the influence of oil price changes on stock market innovations is likely to vary during the period of stable economic growths and downturns. Throughout the implied estimation period of 2001 to 2014, stock market indices have followed frequent continuous growth trends as well as the trends of continuous drop in values during the recessions (see, figure 4, 5 & 6 in section 4). The volatility in stock markets as well reflect the inconsistency during the varying economic cycle. To accommodate such dynamic behavior in stock market index innovations, a two states markov regime-switching model has been implied which seeks to identify two distinct economic-regimes within the markets under consideration. A typical regime-switching model specifies particular structure for common trends and allows switching between the structures. Incorporating such a model, possible economic-regime dependent dynamic relationship between oil price shocks and

[2]Country's level of dependency on oil has been obtained as annual net oil-export or net-oil import as the percentage of respective GDP.

[3] Norway, a net-oil exporting country, is included in the analysis later to justify any insignificant results obtained for Saudi Arabia.

stock market index innovations has been sought out in both oil-exporting and oil-importing countries. Before the analysis, at this point, it would be rational to expect a differential effect (possibly in both magnitude and direction) of oil price changes on stock market innovations during two varying economic-regimes in oil-importing and oil-exporting countries.

1.2. Importance and Contribution

Previous studies on oil price role in economies are found primarily focused on interaction among oil price and economies (GDP) or stock returns mainly in US market. Nevertheless, few other studies, like Gjerde and Saettem (1999); Magyerehe (2004); Ono (2011); Park and Ratti (2008); among others, have extension to other developing and emerging European and Asian markets. For the advancement in further analysis, market selection based on high dependency on net-export and net-import of oil is perceived to be value adding. Furthermore, estimation period for the purpose of this thesis includes dramatic oil price shocks and trends of fragile stock market performances between 2005 and 2012. Analysis implying a dynamic model to cope with such variations attempts to justify the long term optimal relationship between oil price changes and stock market behavior.

A mean model, Vector Autoregressive (VAR, now onwards) model, has been a base model in oil price related literature (for instance see, Cunado and Gracia, 2014; Fayyad and Daly, 2011; Park and Ratti, 2008; Sadorsky, 1999; among others). Another aspect of financial studies, risk assessment, seems left with less attention. Novel attempt[4] of assessing oil price risk on stock market implying Extended regime-switching GARCH model is perceived to be an important contribution in energy related literature. Application of a structural break model by itself omits the problem related to economic-regimes identification on manual break down[5] methodology. Flexibility of a regime-switching model to capture any possible inconsistent macroeconomic relationship (see for instance, Hamilton and Susmel, 1994) within the estimation period is considered a visible merit.

[4] To the authors knowledge implied 'Extended regime-switching GARCH model' in this thesis is a novel application to study the dynamic relationship between stock market volatility and oil price shocks. It is considered that an augmented single-regime GARCH structure has been implied beforehand (for instance, Narayan and Sharma, 2014).

[5] Manual break down methodology refers to the application of two identical structures for theoretically assumed two economic regimes to be estimated separately.

With the abundant use of oil in multi-sector of production and development, it has remained always a factor that directly or indirectly affects the economy and the stock markets. Recent slump in oil price globally has been disadvantageous at least for some of the oil trading economies like Russia. Within the context of such a practical economic importance of the oil price, the result of research here is expected to be worthwhile for academic professionals and stock market investors. For policy makers in oil exporting and importing economies it is vital to understand consequences of changing oil prices. This study helps in formulating the policies to control the possible speculation in financial markets and flourish the market efficiency.

1.3. Research Question Explanation

Reoccurring unexpected changes in macroeconomic factors affect the balance in economic activities. Accordingly, long term economic environment integrates stable and unstable growth periods. Regarding the stock market performance, generally returns are assumed to be higher and consistent during the stable economic environment compared to that during unstable environment (recessions). Some empirical researches like Henry (2009) and Walid et al. (2011) have concluded statistically and economically separated two regimes on modeling long term stock market returns. In their analysis, period of economic instability is coincided to low mean return regime. Accordingly, regarding the stock markets in oil-exporting and oil-importing countries under analysis, the first research quest of this thesis is;

1. *Does long term stock market movement in oil-importing and oil-exporting target countries incorporate two distinct regimes with different level of return and risk?*

Referring some studies, Gray (1996) for instance, in stock returns and interest rate modeling, the shortcomings of mean models are solved simply by volatility models implication. The volatility clustering characteristics of time series (stock return or even interest rate) are often captured well by volatility models. Hence, in this research, the switching volatility model is expected to capture the characteristics of the stock market innovations compared to switching mean model. Past shocks in stock market may have different impact on stock return volatility during the different economic situations. Alternatively, the regime-switching volatility model is expected to overcome the single-regime volatility model on modeling the stock market dynamics. On this basis, the second research question is as follows;

2. *In the context of univariate stock market volatility modelling, does regime-switching volatility model outperform regime-switching mean and single-regime volatility models?*

A positive result in response to question 2 allows to make further extension on the implied regime-switching volatility model. Earlier findings have concluded varying (mostly opposite) relationship of oil price changes to stock returns of; (i) oil & gas industry and other industries, and (ii) oil-exporting countries and oil-importing countries. Ei-Sharif et al. (2005); Nandha et al. (2008); Ramos and Veiga (2011); Sadorsky, (2001); among others, have concluded a direct relationship between oil price shocks and stock return of oil and gas companies (industry). Similarly, Bojorland, (2009); Park and Ratti (2008) & Wang et al., (2013) came up with direct impact of oil price changes to stock market return of oil-exporting economies. Whereas, most of the oil-importing countries stock market returns are found to be negatively correlated to oil prices changes (for instance see, Bhar and Nikolova, 2009; Chiou and Lee, 2009; Cunado and Gracia, 2014; among others). Accordingly, one would take it rational to expect lagged oil price changes influence the stock market return in target oil-exporting and oil-importing countries. Exporting country benefits the wealth transferred from importing countries for any rise in oil price. Consequently, our purposed third research question is;

3. *Is there positive (negative) relationship between oil price changes and stock market return of target oil-exporting (oil-importing) countries? Does this relationship vary in two different economic-regimes?*

Marquering and Verbeek (2004) argue that the factors affecting the stock returns also affect the stock return volatility. Few more studies, for instance, Aloui and Jammazi (2009); Arouri et al. (2012); & Narayan and Sharma (2014) have documented a significant impact of oil price changes on stock return volatility. Within such a scenario, the fifth research question under consideration in this thesis is;

4. *Does oil price changes contribute to intensify the risk in stock markets of target oil-exporting and oil-importing countries? If it does, is the relationship consistent during the varying economic-regimes?*

1.4. Limitations

The structure of implied Extended regime-switching volatility model, the mean return as well as the variance are allowed to be affected by a solo impact oil price changes. Thus, target markets to be the countries with high net export (net import) of oil as the percentage of GDP has been chosen for the purpose of fitness to the implied model. This also means that economic interpretation of the results is limited to the economies where oil-export or oil-import accounts for a significant portion of the overall national economy (GDP). Further the dollar amount of net oil-export or net-import could be higher in other economies. Also the perception regarding the oil price impact on overall industrialized economies around the globe has been well accepted by the earlier literature. Practically oil price impact are more visible in a country like Russia which do not meet the specified market selection criteria. Particularly, volatility of stock markets in oil-importing emerging economies could be highly affected by movements in oil prices. Comparatively less efficient market mechanism and unavailability of alternative energy sources may turn such markets vulnerable to oil price changes.

As a common global oil price indicator, Crude oil Brent FOB total return index, (in US dollars) have been applied for all the target markets to reduce the possible impact of currency exchange rate. Though all the global benchmark oil price indices available are highly correlated (Driesrong et al., 2008), the impact of a country specific oil price mechanism has not been covered within. Regarding the indicator of oil price changes, Hamilton (1996) and Lee et al. (1995) have implied the specification as net oil price increases (NOPI hereafter) and oil price shocks, respectively. These definitions have different specifications to oil price changes. In contrast, a simple transformation as percentage change in oil price with respect to last week oil price represents ‘oil price changes’ for the analysis in this thesis.

Kilian and Park (2009) argue on the asymmetric impact of oil price shocks based on the cause behind the shocks. Their empirical findings indicate a significant impact of oil price shocks on stock return, though the nature and level of impact depends on shocks’ category. Ideally this thesis research has not classified the types of oil price shock but the asymmetric influence has been assumed to be addressed by the regimes categorization in stock market behavior (stable and unstable economic growth periods.

1.5. Structure of the Thesis

The structure of this thesis is followed in congruent to empirical research papers. Concept development and statistical tests are carried out in different headings. ‘Introduction’ comprises the background study of the topic and detection of legging innovation as research questions. Also the importance of the study in topic of interest, and limitation to applied methodology and procedure are discussed under the same heading as discussed before. ‘Empirical Literature’ incorporates the discussion of earlier findings related to the topic and some critics on them. Previous literature have been reviewed in three different categories according to the selection of markets, industries and empirical models. Economical and statistical analysis have been followed to judge the research questions. ‘Methodology’ incorporates both the conceptual framework as well as the empirical framework of the analysis. Conceptual framework includes the discussion of theoretical link between stock market return (volatility) and oil price changes. Empirical framework within Methodology presents the implied econometric model specifications. Brief documentation of models estimation methods are then followed. Aside, ‘Data Description and Preliminary Analysis’ presents the nature of series under analysis and their basic economic interpretation. To follow, ‘Empirical results’ includes statistical results obtained from the employed estimations. The statistical significance and interpretation are accompanied to the results. Finally, ‘Conclusion’ includes the economic interpretation of the empirical results and the practical implication of this research. Further research extensions on the economic agenda and applicable models are too included in later part of the conclusion.

2. EMPIRICAL LITERATURE

Documentation of oil price as a determinant variable into economy has a long history. Most probably the pioneering empirical work started from Hamilton (1983), which measured the impact of oil price shocks into economy in reference to fluctuation caused in GNP[6] of USA. Since then the oil price related study has been made broad into several dimensions. Studies have been extended from US to other developed nations, emerging markets, geographical identifications, and as well the single country’s economy. Within such specifications for analysis, the nature of the results obtained from these studies have not been always identical. Despite the mostly common results and interpretation, there

[6] World Bank refers gross national income (GNI) as former GNP.

also exist some well accepted researches that have come up with the opposing results. Taking into account that the oil as a commodity, study criteria has been made broader into industrial divisions as oil and gas industries versus non-oil related industries. As far the author's knowledge, rarely some studies exist with the main specification as importer or exporter of oil. Topic of interest for review is on interaction between volatility in stock returns and oil price changes. Most of these earlier studies have been conducted on mean modeling of stock return. With the development of statistical tools into econometric analysis, the methodology of empirical tests and modelling has been revised, modified and newly evolved. As mentioned in the earlier sections, the mostly implied model in investigation of relationship between oil price and stock return is considered to be Vector Auto-regression (VAR). Alongside, Vector Auto Correction Model (VECM), Multivariate Linear Regression and Multifactor Market Model are equally popular regarding the study of similar relationship. Importantly, during the later phase of research history, the use of volatility models like, GARCH, E-GARCH, Structural breaks model, switching mean and volatility models have been evolved. With such a broadly characterized framework of literature, the following section of the literature review is made according to the economy, industry, model selections.

2.1. Literature Review on Country Analysis

The correlation between oil price and output (GNP) is not just the statistical coincidence. The movement in oil price during and before the duration of change in output is of suspicious systematic relationship. Making a pioneering research in the aspect of oil price, Hamilton (1983) has proved that U.S. output was directly related to the lagged change in oil price. U.S. recessions are normally preceded by the dramatic rise in oil price which has led to fall in economic output. Later in 1996, the study was made broader by considering the stock return as the measure of economic endogenous variable which could be influenced by the shocks in oil price. In line with this study, similar research on United States, Canada, Japan and United Kingdom have concluded the detrimental impact of oil price changes on output and real stock returns in all these economies (Jones and Kaul, 1996). However, the rationalities of stock market were found much inherent in United States and Canada as reaction on stock returns to oil price changes were accurately reflected by the impact on current and expected real cash flows. Partly contrary to these early studies, Huang et al. (1996) conducted an empirical test on lead-lag relationship between oil price futures and stock returns of S&P 500, 12 industries stock indices and 3 individual oil companies. By controlling the so called important economic impact variables, like interest rate effects and seasonality effects, they have found no significant correlation between oil price futures and stock returns except in the case of oil companies' stock returns. Even though the oil companies and petroleum index return was significantly affected by oil price changes, the profitability on trading oil stocks for investors upon change in oil futures price would mostly be negative as the bid-ask spread in stocks were higher. Thus, the investigation suggests that the information contained in oil futures price change would not be of importance to public investors.

Using monthly data from 1947 to 1996, Sadorsky (1999) tested the 'symmetric and asymmetric' effect of oil price shocks and oil price volatility shocks on S&P 500 returns. The relationship chain in between economic variables, namely: - interest rate, followed by oil prices changes or oil price volatility, industrial production and stock returns has been developed as a system into a VAR model. As an innovation, oil price volatility in this study has been calculated using GARCH model for oil price changes. Oil price changes and oil price volatilities are used in the VAR model alternatively but not together. In aggregate, the study emphasizes the possibility of inflationary pressure arose by the movements in oil prices which in turn could shape the interest rate as well as other securities investments. The focused conclusion from the study was both the oil price shocks and its' volatility shocks affect the economy. The alternate phenomenon of economic activities to shape the oil prices was found less significant. Distinctly, the relationship between oil price changes and real stock returns has been found negatively correlated. Oil price volatility shocks also showed asymmetric effects on the economy. The evidence has been presented as the more importance of oil price movement in explaining the forecast error variance of stock returns than do the interest rates.

In the environment that the earlier studies being focused in developed economies, Papapetrou (2001) studied the relationship between oil prices and economic activities in Greece. This study explains the necessity of research extension to small and medium sized OECD economies to better understand whether the relationship is a common universal phenomenon. Here, the impact of oil price changes has been tested on both the employment and output in Greece. Market selection in this study could be of importance as Greece had been a net importer of oil among the medium sized economies. Data range of 1989 to1999 was applied in VAR model using the similar economic variables system as in Sadorsky (1999), in exception to additional use of industrial employment as a measure of employment variable within the chain. The first part of the conclusion in this study has been drawn as such that the oil price shocks have immediate indirect relationship with industrial output and employment. The second section of the conclusion through the empirical findings is that the stock returns in Greece are depressed by the positive change in oil prices.

So far, especially in United States economy, the relationship between oil price shocks and stock returns were found statistically and economically significant with mostly the indirect association. The findings of Huang et al. (1996) were striking. Making a further research on their findings, Ciner (2001) tested a non-linear association between oil price futures and stock returns for the same data used in Huang et al. (1996). Using the modified Beak and Brock (1992) test introduced by Hiemstra and Jones (1994), Ciner (2001) assessed the non-linear Granger causality between the oil price future returns and stock returns. This investigation concluded a nonlinear relationship between oil price shocks and U.S stock returns, indeed. Since then, the innovative theme in studying the linkage between oil price and stock market was developed to be a non-linear dependency.

Further contribution on the topic by Huang et al. (2005) focused on asymmetric impact of oil price shocks on economic activities. The study on US, Canada and Japan is based on two regimes of economic activities. In their research paper, they argue that the degree of oil dependencies in each economy varies as the threshold level in the analysis was different for different economy. Importantly, the impact of oil price changes on stock market returns were found limited in a regime that falls below the threshold but were significant in the other regime, in a two regime framework. Comparatively, they have found that the oil price changes rather than oil price volatility have better explanatory power on shaping the economic activities. The conclusion that the impact of oil price movement in stock returns depends on the level of oil dependencies of the particular economies has shed a seed of research idea for this thesis too.

Stock market returns of the U.S. and 13 European countries were brought into consideration by Park and Ratti (2008). With the purpose of judgment of common relationship in between oil price movement and stock returns across different economies, they have used unrestricted multivariate VAR method, incorporating the possible spillover effect from U.S. stock market to European stock markets. Allowing for the spillover effect in the U.K., oil price shock was found depressing the stock market return in particular. Also the volatility of oil prices has affected negatively on real stock market return in most of the European countries but not in U.S. In exception to other countries, Norway as an oil exporter has resulted significant positive association between oil price increase and the real stock returns. In line with previous studies, the impact of oil price shocks to variability in real stock returns, in most of the countries under analysis, was greater than that of interest rate.

In 2008, the effectiveness of monetary policy regarding the control of consequences by oil price shocks in U.S. economy has been studied. The linear and nonlinear measures of oil price shocks were implied to model the U.S. stock market return. Furthermore, the impact of monetary policy shocks along with oil price shocks to stock returns has been regressed. This analysis has concluded that the monetary policy play no role in transmission of oil price shocks to the economy (Bachmeier, 2008). Oil price shocks were found significantly affecting the U.S. stock returns even if the Federal Reserve makes no response to oil price shocks.

With a title indicating 'The stock return appreciation in oil exporting country by the positive change in oil prices', Bjornland (2009) conducted a VAR analysis in Norwegian stock market returns. Monthly data from 1993 to 2005 has been used in this study, where the possible impact of monetary policy into inflation control and financial markets are incorporated as a detrimental economic variable. The research conclusion suggests that Norway benefits from the higher oil prices. For a 10% rise in oil prices, stock returns were found to rise by 2-3% though such an effect was found to be short term as it dies out gradually. Nevertheless, one of the important forces driving the Norwegian stock returns was detected to be the monetary policy shocks.

The same year, Chiou and Lee (2009) took S&P 500 stock index returns into Autoregressive Conditional Jump Intensity model to inspect the inter-linkage between oil price and stock market. With such a model implication, the authors argue that this study distinguishes from previous studies as it considers the structural changes in the dependency relationship between oil and financial market. Here too, the shocks in oil price have been assumed to be affecting the cost of production, corporate earnings and cause of inflation and wealth transfer mechanism. Their results have indicated an important economic phenomenon that during the state of high fluctuation in oil price, oil price change has unexpected asymmetric impact on S&P 500 index return. Based on their results, the unexpected asymmetric changes in oil price has negative impact on S&P 500 index return during the high fluctuation state whereas the impact does not hold during the low fluctuation state of oil prices. This result could be considered as the compliment for

Huang et al. (2005) findings. Thus, the study has suggested the importance of hedging oil price risk to maintain the stock return stability.

In the circumstances of growth in emerging markets, the use and importance of oil for production of output is worth considering. Highlighting the emergence of emerging markets as a major section of world's oil consumers, Bhar and Nilolova (2009) considered the BRIC equity markets connection to oil prices. Not only the return dependencies, but also the volatility transmission between oil and equity markets has been studied. Their results have shown that the dynamics of oil price changes has no significant impact in equity returns of BRIC countries except in the case of Russia. Moreover, the volatility of Indian and Chinese stock market returns has been negatively affected by the past innovations of oil price. This could be an important distinction between a pure net importer and exporter of oil. In contrast, Russia being a net exporter for decades, the relationship between the world oil price returns and the AK&M Composite Stock Index returns was found strong. Alongside the stock return volatility has been explained by oil price return spillovers in Russian market. Point of concern from this study can be taken as the negative correlation detected between the global oil price returns and the Russian equity returns. The authors' argument for the reason behind such relationship could be the political and economic resilience in Russia during their estimation period of 1995 to 2007 to shape the global demand and supply mechanism despite the economy being a net exporter.

Now it is well documented that volatility shocks in crude oil markets have significant effects on variety of economic activities (Aloui and Jammazi, 2009, page 789). These authors employed the Extended MS-EGARCH model on stock market returns for three developed economies; Japan, the U.K. and France. Their model for stock market returns and returns volatility accommodates the regime switching behavior and also the impact of oil price changes. Based on the better statistical fit of data into their model specification, the stock return volatility modeling allowing regime switching behavior can be considered as the important outcome of this research. Their findings explores the high mean and low variance regime being much persistent in U.K and France rather than in Japan. Specifically, significant results were drawn regarding the role of oil price change (NOPI) in determining the real stock market returns volatility as well as probability of regime shifts. Fitness the model and its dynamic characteristics in return and volatility modeling is considered a motivating factor. Some of the issues regarding the use of bivariate GARCH type model for such diverged and developed economies are analyzed further in this thesis. Although similar model has been employed in this thesis, the selected markets for analysis with different characteristics are, in the author's perception, assumed to be more realistic.

Extending the structural breaks in oil price shocks depending on the cause behind the shocks of Kilian and Park (2007), a nonlinear relationship between oil price shocks and international stock market returns has been judged by Apergis and Miller (2009). To accommodate the stationary properties of variables in structural VAR model, the variables except stock returns and three series of structural shocks in oil price, have been used as I(1) variables. Such a specification in modeling stock returns has resulted a significant impact of different structural oil price shocks. Though all the structural shocks came to be significant in almost all countries stock returns modeling, the magnitude of such effects were so low. Hence, they concluded that oil price shocks do not affect stock markets returns in a meaningful manner. One of the economic interpretations they have argued is some other control variables like exchange rates and interest rates could better explain the stock market returns. Though such results are rare concerning the study of linkage between oil prices and stock markets, it provides a comprehensive idea of studying the nature behind the oil price shocks and their time varying impact in the economies.

In long term modeling, importance of structural breaks in oil price shocks has been reflected by the number of earlier literature. Miller and Ratti (2009) allowed the break points in oil price to be determined endogenously by performing rolling likelihood ratio tests. Estimation period from 1971 to 2008 has been made on monthly data to capture different trends. Markets analyzed are six developed economies (OECD countries). In their empirical tests, three structural breaks were obtained within the estimation period to be significant in oil price trend. Breaks are clearly apparent in graphical presentation of oil price through the passage of time. Through their findings, oil price breaks are specified as; (i) 1971 to 1980, (ii) 1980 to 1988, (iii) 1988 to 1999, and (iv) 1999 to 2008. For the first two specified break periods, a clear long term relationship has been obtained between stock prices and oil prices with negative correlation coefficient and interpreted as a natural economic phenomenon. But for the latter two breaks period, the previous relationship does not exist. Overall, the stability of the long-run relationship between crude oil and stock market prices over the pre-1999 period with the subsequent disintegration or reversal of this relationship suggests that stock markets have not responded to oil prices in the expected way since then (Miller and Ratti, 2009, page 567). Thus, this finding suggests a change in relationship between oil prices and stock prices before and after 1999.

Nonlinear relationship between stock returns and oil price changes has been further researched. By combining the regime-switching model of Hamilton (1989) and simple linear model of Jones and Kaul (1996), Reboredo (2010) has purposed a modified specification to model the relationship between stock returns and oil price changes. With 246 monthly observations till March 2006, stock market returns of U.S., U.K., Germany and Netherland were analyzed. Consistent to some of the previous studies implying structural breaks, the effect of oil price shocks on stock market indices return was found significantly negative during the regime of high uncertainty. Contrary to Aloui and Jammazi (2009), in this study the transition between the regimes were not significantly affected by the oil price changes or oil price volatilities.

Markov-switching approach got much popular in studies related to oil price impact into economy after 2008. Chen (2010) allowed the S&P stock index return to be modeled into markov-switching framework. In their research, the transition between two specified regimes was allowed to be time dependent and affected by change in oil prices. As some of the related previous studies mentioned the possibility of association between oil price shocks and economic downturns, the statistical quest was set to investigate if the change in oil prices component affects the low mean and high variance stock returns regime. Notably, the estimation period was long enough ranging from 1957 to 2009 on monthly data. Strong and robust evidence has been shown that the higher the oil price, the higher is the probability of switching from a bull market to a bear market (Chen, 2010, page 495). Hence, this study was distinct from those done earlier as it empirically concluded a relationship between oil price shocks and economic recession.

Fayyad and Daly (2011) made a comparative study between GCC countries with the UK and USA in respect to the relation between oil price shocks and stock market returns. Applying the commonly used VAR approach the relationship has been investigated separately in three episodes of oil price referred as the constant, the rising and the falling oil price episodes. Surprisingly, the first episode of constant oil price had no significant impact in stock market returns of all the implied stock markets. The rising oil price episode had mixed impact but the third episode of falling oil price showed significant but varying degrees of impact on stock market returns of all the economies except Kuwait and Bahrain.

Arouri et al. (2012) conducted a study to investigate the possible volatility spillover between oil and stock markets in Europe using the VAR-GARCH approach. They have concluded a significant volatility spillover effect between oil price and stock markets in Europe. The notion that the impact of oil price to stock markets has been perceived to exist as the volatility spillover effect was more dominant from oil price to stock markets. On the basis of varying impact on various sectorial equity returns, the optimal portfolio holding concept is carried out. Such a portfolio with appropriate hedge ratio could help to reduce the oil price risk and obtain the adjusted performance.

A recent study in Saudi Arabia market (Jouini, 2013) revealed that in fact the spillover is more prominent in returns from oil to stock rather than the volatilities. Their study concludes that in Saudi Arabia (a pure net exporter of oil) the shocks in oil are vehicle to drive the stock prices. Whereas the VAR-GARCH modeling resulted that the volatility transmission is more effective from stock market to oil. Among the important findings, returns spillover was detected highly significant during the crisis period in Saudi Arabia. This result adds up the motivation to judge the possible nonlinear relationship between oil price changes and stock returns of net oil exporting country, like Saudi Arabia, that varies in both magnitude and direction during the stable and unstable economic conditions.

With a clear distinction among oil trading economies, Wang et al. (2013) made a structural VAR analysis to investigate the relationship between world oil price and stock prices. Oil price impact on economies of net oil exporters and net oil importers is of crucial interest as the studies reviewed so far have not made such a comparative study. Accordingly, the impact level, duration and direction of oil price changes to stock returns of net exporter and net importers varied. This study comprises 9 major oil exporting and 7 major importing countries with monthly data from 1999 to 2011. Similar results to some of the earlier reviews, the oil price shocks impact was found detrimental depending on whether the changes in oil price are demand or supply driven. The other factor determining the level of effect was found to be the importance of oil to that particular economy. Comparatively, stock returns in oil exporting countries were found more affected by aggregate demand shocks of oil price in importing countries. Co-movement in stock returns of oil exporting countries was found significant but was insignificant for oil importing countries.

Consecutively, the oil price impacts in 12 European oil importing economies has been concluded similar to the commonly obtained results. A significant negative correlation was obtained in between oil price shocks and stock returns in all the oil importing nations. A long evaluation period (from 1973 to 2011, monthly) has been modeled using VAR and VECM. Again, the cause behind the oil price shock has been found effective in shaping the stock market returns. In Wang et al. (2013) stock market return of net oil exporters were significantly positively influenced by aggregate demand shocks in oil price. Contrary to that, the supply shocks tend to impact negatively and more significantly on net oil importing countries' stock returns. One of the practical interpretations explained in this paper states that some oil supply shocks like Iranian revolution 1979 and Gulf war 1990, rises the oil prices in oil importing countries and hence the relationship is negative and significant.

2.2. Literature Review on Industry Analysis

Before 2000, most of the literature on relationship between oil price and economies are found focused on country specification. More specifically, those literature refer oil price effect on stock market returns or GDP. An important issue about the impact oil price changes on specific company's stock return or on specific industry stock index return became crucial. Companies directly related to oil business must have been affected much than other companies by the fluctuations in oil prices. Referring the discounted cash flow approach of stock valuation too, the impact of oil price changes on current as well as the expected cash flows of such companies can be perceived high. Accordingly many studies have been made to judge the relationship between oil price changes and stock returns of industries and individual companies. Some of such inspiring studies are reviewed here to make some critical analysis and obtain the existing development on the topic of interest.

Sadorsky (2001) have conducted a study on oil and gas industry stock prices of Canada. A multifactor market model consisting of exchange rates, crude oil prices and interest rates have been developed to model the stock returns. The empirical result from this study suggests that all of these variables have significant positive impact on oil and gas industry stock returns. Also, in Canada, the oil and gas industry stock return was found less risky than the market which moves pro-cyclical. So the results indicate that investors cannot take oil and gas industries stock as a hedge against inflation.

A similar study, as Sadorsky (2001), was followed in a different country. Economic literature on oil price effects have uniformly accepted a linkage that oil price has a significant impact on developed economy. Accordingly, Ei-Sharif et al. (2005) have chosen United Kingdom in their analysis to study the relationship between oil price changes and stock returns of oil and gas companies within the country. The model and variables are similar to that used in Sadorsky (2001). For further understanding of specific impact of oil price changes on oil and gas industry, stock return of other industries with similar as well as varying characteristics were too modelled. Inline to Canadian oil and gas industry, the coefficient was positive. This evidence indicates that, as expected, an increase (decrease) in oil prices is reflected in positive (negative) returns being earned by shares in the sector (Ei-Sharif et al., 2005 page 824). Comparative results among four other sectors under consideration indicate a weak relationship between oil prices and equity values. Thus the result suggests that the industries are not homogeneous as different factors may impact returns of different industries differently.

Using two step regression analyses under different arbitrage pricing models, Scholtens and Wang (2008) have assessed the oil price sensitivity of NYSE listed oil and gas firms. They aimed to find whether oil risk is priced in oil and gas stocks. They also found an evidence that most of the oil and gas stock returns are positively related to the market return and oil price changes. Under their integrated model, a significant oil risk premium has been detected which means investors require higher returns from oil firms for oil price sensitivity. One of the weaknesses of the commonly used macroeconomic model has been pointed as this model did not account for the oil price risk into stock returns. Here too, the oil and gas firms have been found less risky than the market as a whole. As well, results from Fama and French factor model concluded that the oil firms with high book to market ratio are likely for higher returns.

Nandha and Faff (2008) analyzed 35 DataStream global industry indices to examine the impact of oil price shocks on stock index returns of different sectors. They found negative impact of oil price shocks on stock returns of all the sectors in exception to mining, and oil and gas industries. Generally, these results are consistent with economic theory and evidence provided by previous empirical studies (Nandha and Faff, 2008, page 986). Their findings further suggests for inclusion of oil firms stock into the portfolio of international investment or hedge the oil price risk to benefit from diversification.

Research on oil price and stock returns had already been made on classification depending on book to market value of the stocks. Interestingly, Sadorsky (2008) studied the relationship letting the stock return to vary with the firm's sizes. A list of 1500 firms, classified as large firms, medium-sized firms and small firms, were taken into evaluation from S&P 1500. Empirical results of the implied multi-factor model suggests that oil price changes indeed affects the stock returns and the effect varies according to the size of the firm. He found a negative association in between the stock returns and the oil price changes. However, the most affected categories are the medium-sized firms. Medium-sized firms do not enjoy the production efficiency and financial leverage of large firms nor do they have the flexibility and responsiveness of small firms (Sadorsky, 2008, page 3861).

Similar to the positive relationship of stock returns of oil and gas companies to oil price changes, the stock returns of alternative energy companies are perceived to be positively associated with the oil price changes. But empirical studies on such studies are found rare. Nevertheless, Henriques and Sadorsky (2008) developed a VAR model to assess the relationship between alternative energy stock prices, technology stock prices, oil prices and interest rates. They have used WilderHill Clean Energy Index to measure the returns of alternative energy companies. Their results suggest that all the variables implied in the model have some degree of influence on stock return of alternative energy companies. Even then the technology stock return has higher and significant impact than oil prices shocks do. In other words, as expressed by the authors, alternative energy companies are yet not adopted as mainstream energy companies. Rather, the higher association between technology stocks return and returns of alternative energy companies refers that investors may view alternative energy companies as other high tech companies.

China has been a focal point of business operation and production centre for years now. In such a situation, china has been net importer of oil for several years too. Thus it is crucial to examine the impact of oil price changes on Chinese stock market. With such an idea Cong et al. (2008) implied VAR model to stock returns of two Chinese stock market indices along with stock returns of industry classification indices and four oil companies' stock prices. In china, a bit different to other economies, the relationship came insignificant in most of the indices except manufacturing index and some oil companies' stock returns. The domestic oil price shocks were found more significant than the world oil price shocks. This would mean that exchange rate is taken into consideration while trading the stocks. Rather than the oil companies stock returns, the Chinese manufacturing industry index return came significantly affected by oil price shocks.

A contrasting result to earlier studies is obtained in Monhanty et al. (2010) regarding the impact of oil price shocks in stock returns of oil and gas sectors. Using the monthly data from 1998 to 2010, a two-factor model is implied to judge the relationship of oil and gas sector returns from central and eastern European region with oil price changes. On their both analysis; firm level as well as industry level, no significant relationship between equity returns of oil and gas companies and oil price changes has been observed. The authors interpret the result as such that in emerging or transitional economies, the market mechanism does not work as smoothly as it does in developed markets.

In search of risk factors in oil and gas industries in 34 different countries a researched has been made. Surprising ups and downs in oil prices during 2004-2010 have pulled investors' attention towards the oil and gas companies stocks in quest of returns and diversification benefits (Ramos and Veiga, 2011). Their empirical analysis concludes that the oil prices changes have strong impact on oil and gas sector of developed countries than in emerging countries. In addition, evidence of asymmetric effects of oil price changes has been observed. The rise in oil prices was found to be more influential to oil and gas companies stock returns than the oil prices drop. In their comparative analysis, this asymmetrical effect of oil prices to oil and gas industries stocks is unique unlike the effects of commodities price changes on commodity-driven industry stock returns.

Allowing the lagged oil price growth rate into the variance equation of GARCH(1,1) model for 14 industrial sectors stock returns, Narayan and Sharma (2014) accessed the impact of oil price changes on stock returns volatility. Varying impact of oil price changes has been observed for different sectors return volatility. Unlike other sectors, the banking sectors volatility rises with the rise in oil prices. An additional evidence of firms' heterogeneity was found in respect to firm size. Regarding the forecast accuracy, their model made more accuracy than the historical averages, which is purposed to be a vehicle for investors to improve their earnings.

Overall, the connection between oil price and different industries stock return is observed to be varying. Similar to that of most of the oil exporting countries, the oil and gas companies are also positively affected by the change in oil prices. Other industrial sectors have relatively low impact of oil price changes or even opposite relationship. With no ignorance, the oil price impact on oil and gas companies stock is varying depending on firm size and location. Medium sized companies are more affected by change in oil prices. Notably, the firms in emerging and transition economies are found less affected by oil price shocks than firms in developed economies.

2.3. Literature Review on Applied Empirical Method

Occasionally the above mentioned literature are reviewed and documented along with their implied empirical models. Here in this section a short discussion is made regarding the models used in accessing the relationship. With the rise in studies about the topic, many critics have been made on earlier models and new models are purposed to capture the relationship as closely. Interesting facts are found as such that the results from a previously implied model are altered and interpreted right the opposite way by the implication of more complex models.

With the introductory use by Hamilton (1983), normal linear regression has been used in many of the related researches. Such a regression model is used with different indication as market model, multiple regression, multifactor market model, two factor linear model, etc. (see, for example, Jones and Kaul, 1996; Ramos and Veiga, 2011; Sadorsky, 2001; among others). In such model mostly the modeling of stock returns is considered to be a macroeconomic phenomenon. Thus the macro economic variables like interest rates, exchange rates, industrial production, global oil prices, etc. are used to be the detrimental variables. Nevertheless, some findings are based on just two factors model too. The analytical view on use of less detrimental variables on modeling a macroeconomic phenomenon can be less realistic meaning that the control effect of rest of the missing macro-economic variables would be ignored.

Most of the reviewed literature for oil price impact on stock market is being made using the Vector Autoregressive (VAR) model. As the assessment topic is a macroeconomic phenomenon, any of the macro economic variables may be a cause factor of the other one. VAR simplifies this issue as it allows all the involving variables to be endogenous and exogenous to each other. The VAR model in previous studies is sometimes used as multivariate VAR and in some cases accompanied by the vector error correction model (VECM). For instance, the literature like Apergis and Miller (2009), Cunado and Gracia (2014), Park and Ratti (2008), Ramos and Veiga (2011), Sadorsky (1999), among others have implied such models.

Ceitin (2001) used the linear and nonlinear causality tests through which he found non-linear relationship between oil prices futures returns and stock market returns. An analysis on the same data was previously concluded as a statistically insignificant relationship by Huang et al. (1996) using the linear multivariate VAR model. Following this, Huang et al. (2005) realized the non-linear relationship and used multivariate threshold model that resulted a significant asymmetric relationship between oil price changes and stock market returns. Later, Bachmeier (2008) has also used threshold model along with other linear models.

Since the results of asymmetric and non-linear relationship between oil price changes and stock returns had already been proved in different markets, a concept of structural break and switching model began to emerge after 2008. An additional motivation for the use of such models could be that the drastic changes in behavior of oil prices as well as stock return during unstable economic situations. History of oil price also shows that the political events and wars also have affected the behavior of oil price changes. Consequently, Aloui and Jammazi (2009), Bhar and Nikolova (2009), Chen (2010), Reboredo (2010), among others used the switching models that distinctly model the relationship varying with the time and trends in the exogenous variable. Switching model has been used by incorporating the mean models like MS-AR and MS-simple linear regression as well the volatility models like MS-ARCH and MS-EGARCH.

VAR-GARCH model is also well accepted among other model used. Arouri et al. (2012) have implied VAR-GARCH mode to access the volatility spillover between oil and stock markets in Europe. Similarly, Jouini (2013) also used VAR-GARCH model, through which a unilateral return spillover effect from oil market to stock sector was detected in Saudi Arabia. Some other models detected in the review were Autoregressive Conditional Jump Intensity (ARJI) model used by Chiou and Lee (2009) and structural break rolling likelihood test ratio by Miller and Ratti (2009).

3. METHODOLOGY

3.1. Conceptual Framework

Oil, as a factor of production for companies within the stock market, plays a detrimental role on stock market returns and volatility. The qualitative inference between stock market and oil prices is discussed below.

3.1.1. Stock market return and oil price changes

Based on stock market efficiency, the possible path of stock market infection by the changes in oil price has been discussed in the earlier sections. For further clarity on the possible conditional relationship between stock market return and oil price changes this section has been developed fairly illustrative. Huang et al. (1996) have purposed a clear linkage between stock returns and oil price changes and has been widely accepted by recent literature (for instance see Jones et al., 2004; Nandha and Faff (2008); Narayan and Sharma, 2014; among others). They have elaborated that according to Discounted Cash Flow approach of stock valuation, stock prices are the discounted values of expected future cash flows. This can be expressed as:

$$P = \frac{E(c)}{E(r)}$$

where, *P* is the stock price, c is the cash flow stream and r is the discount rate, and E (.) is the expectation operator.

Following this, the realized stock return, *R*, can be given as:

$$R = \frac{d(E(c))}{E(c)} - \frac{d(E(r)}{E(r)}$$

where, d (.) is the differentiation operator.

Based on this expression, any systematic movements in expected cash flows and discount rate affect the stock return.

As an illustration, oil price has been a key input for many companies directly or indirectly. Any rise in price of oil will increase the cost of production. Alternately, this will reduce the profitability and expected cash flows. Thus, reduction of expected cash flows reduces the stock prices. Regarding the expected discount rate infection, any expected change in oil price matters the level of expected inflation. Discount rate is the systematic combination of expected real interest rate and expected inflation. Consecutively, the change in oil price is closely related to change in inflation and in turn, affects the expected discount rate. Such changes in expected discount rate affect the stock prices. Importantly, the direction of affect depends on whether the company is net producer or net consumer of oil. But in aggregate, globally the oil is an input, and hence the rise in oil price would decrease the overall stock prices.

3.1.2. Stock market volatility and oil price changes

Earlier literature on interaction between oil price and stock market have been primarily focused to oil price shocks effects on stock returns. Stock return volatility has been shadowed with less attention. Few exception (for example Marquering and Verbeek, 2004) have mentioned the relationship between stock return volatility and oil price changes though a clear empirical framework is still lacking. Nevertheless, a recent study by Narayan and Sharma (2014) has concluded with significant relationship between oil price changes and stock return volatility. Conceptual framework below for the relationship between Oil price changes and stock market volatility is based on their explanation.

Transfer of wealth from importing nation to exporting nation enhance the purchasing power and the consumer demand in oil exporting economy whereas the consumer demand falls in oil importing economy. In aggregate the world demand for goods produced in importing economies decreases and supply of savings rises. In macroeconomic view this causes the real interest rate to increase. Now, the construct is easily comparable with the stock return, stock return volatility and real interest rate change. With the rise in real interest rate, the required rate of return rises for equity investors and equity prices fall. Thus investors restructure their portfolio towards more weight on bonds. This may change the stock return volatility.

Addition to this, Marquering and Verbeek (2004) extend their argument that factors affecting stock return and stock return volatility are common. The detrimental influence of oil price shocks on stock returns is evident from widely accepted literature. Congruently oil price shocks affect stock return volatility. Another theoretical extraction from Narayan and Sharma (2014) is that the increase in money demand caused by the rise in oil price could be controlled by the monetary authorities. If any measure to change the money supply is made to meet the growing demand, this will change expected inflation and encourage in portfolio substitutions. It is more likely that monetary authorities will make the buys and sells of bond to adjust the bank reserves and money supply. Thus this will lead to affect the financial markets and the stock return volatility. To sum up, the relationship between oil price changes and stock market return volatility can be linked with the change in interest rate, inflation rate and money supply in both oil-exporting and oil-importing nations.

3.2. Empirical Framework

This thesis concerns on modeling long term stock market return and volatility. Theoretical sections above has developed a qualitative framework for the objective of the thesis. Accordingly research questions are formulated for quantitative tests and evaluation. Two different economic-regimes are perceived in stock markets performance behaviour and are distinguished by using two states markov switching phenomenon. Hence, the analysis here proceeds with the simple regression model compared with markov two state specification model under the similar structure. Specifically, the single regime mean models are constructed and then are compared with structurally identical switching mean models. This enhances the analysis to observe if switching model better fits the data, statistically and economically. First section of the empirical analysis begins with the univariate mean modeling of stock returns followed by the univariate and bivariate volatility models. Both the mean models and volatility models are developed in two regimes specifications along with the single regime structure. Frameworks and expressions of the implied models are now discussed in turn.

3.2.1. Single-regime constant mean and constant variance model

Long term mean of the stock returns has been obtained using a regression on a constant parameter. In this approach both the mean return and the return variance are assumed constant for the whole estimation period. Coefficients obtained from this model represent the mean and the volatility of the stock market returns under consideration. The model is specified as;

$r_t = a_{01} + u_{t,}$

More specifically,

$r_t \, \text{I}\Phi_t \sim \text{N}(\, a_{01}, b_{01})$ (1.10)

where, r_t is stock market return at time t. a_{01} and b_{01} are the constant mean and constant standard deviation of the stock market returns.

Ordinary least square (OLS, hereafter) technique is applied for the estimation of these parameters.

3.2.2. Regime-switching constant mean and constant variance model

To consider the long term heteroscedasticity in residuals, two states markov switching model is implied which is assumed to capture the heteroscedasticity by itself. In other words, any conditional heteroskedsticity can only be driven by switches between regimes (gray, 1996, page 39). The switching between the regimes is governed by a first–order markov process with state dependent probabilities. According to Engel and Hamilton (1990), the state dependent probabilities can be given as;

$p \; (s_t = 1\text{I}s_{t-1} = 1) = p_{11}$
$p \; (s_t = 2\text{I}s_{t-1} = 1) = 1 - p_{11}$
$p \; (s_t = 1\text{I}s_{t-1} = 2) = 1 - p_{22}$
$p \; (s_t = 2\text{I}s_{t-1} = 2) = p_{22}$

where, p_{11} & $(1 - p_{11})$ are the probabilities of being in state 1 & state 2, respectively regarding the immediate previous state was $S_{t-1} = 1$. Similarly, p_{22} & $(1 - p_{22})$ are the probabilities of being in state 2 & state 1, respectively regarding the immediate previous state was $S_{t-1} = 2$. The past realization of stock market return and state are assumed to be solely represented by $S_{t-1.}$ S_t is assumed to depend on $S_{t-1.}$

Now the specification of regime-switching constant mean and constant variance model is given as;

$$r_t \, \text{I}\Phi_t \sim \begin{pmatrix} N(\text{a01, b01}) & \text{w.p.} & pt \\ N(\text{a02, b02}) & \text{w.p.} & 1-p\text{t} \end{pmatrix} \qquad (1.11)$$

Broyden-Fletcher-Goldfarb-Shanno (BFGS) estimation technique is applied for the parameter estimation in eqn (1.11).

According to Gray (1996), markov two state fixed transition probabilities can be given as;

$$p_{1t} = (1-p_{22}) \left[\frac{g_{2t-1}(1-p_{1t-1})}{g_{1t-1}p_{1t-1} + g_{2t-1}(1-p_{1t-1})}\right] + p_{11} \left[\frac{g_{1t-1}(1-p_{1t-1})}{g_{1t-1}p_{1t-1} + g_{2t-1}(1-p_{1t-1})}\right] \qquad (1.12)$$

$$g_{1t} = f(r_t | S_t = 1), \qquad g_{2t} = f(r_t | S_t = 2)$$

Throughout the research in this thesis, the transition probabilities are assumed to be constant. Regarding the earlier researches, the role of oil price changes to affect the transition of regimes in stock market returns is of mixed findings. Chen (2010) argues that the oil price changes influence the shift between the regimes whereas Reboredo (2010) concludes with no impact of oil price in switching between the regimes in stock market return, for instance.

Using the above mentioned two models, a distinction of different economic phenomenon during different time periods could be tested. To follow the similar procedure of comparing the mean models of single-regime and regime-switching frameworks the following models are implied.

3.2.3. Single-regime AR(1) model with constant variance

For the further analysis of the preliminary consideration on regime-switching by itself able to capture the conditional heteroscedasticity in stock market return residuals, the constant mean model is adjusted to autoregressive (AR) model. In this model the current value of the exogenous variable depends on its own lag values and the error term. Brooks (2008) express the AR model in sigma notation as;

$$y_t = \mu + \sum_{i=1}^{p} \phi y_{t-i} + u_t$$

where, the lag order p is optimally selected through autocorrelation and partial autocorrelation coefficients.

Being specific on autoregressive model used in this thesis, the lag selection is made on standard lag 1. Thus the single-regime AR(1) model implied here can be given as;

$r_t = a_{01} + a_{02}r_{t-1} + u_{t,}$

More specifically,

$$r_t \, I\Phi_{t-1} \sim N(a_{01}+a_{11}r_{t-1}, b_{01}) \qquad (1.13)$$

Parameters a_{01}, a_{11} and b_{01} of eqn (1.13) are estimated using the OLS technique. For the significance test of the estimates, the standard errors and t- values are also obtained.

3.2.4. Regime-switching AR(1) model with constant variance

With the objective of segmented structure in the model for stock market return, the single regime AR(1) model is followed by regime-switching AR(1) model. As mentioned earlier, the probable existence of heteroscedasticity on using single regime AR(1) model is assumed to be solved by the regime switching structure. For the regime-switching AR(1) model, the mathematical expression follows as such;

$$r_t \, I\Phi_{t-1} \sim \begin{pmatrix} N(\mathrm{a01}+\mathrm{a11}rt-1,\ \mathrm{b01}) & \text{w.p.} \ \ pt \\ N(\mathrm{a02}+\mathrm{a12}rt-1,\ \mathrm{b02}) & \text{w.p.} \ \ 1-p\mathrm{t} \end{pmatrix} \qquad (1.14)$$

where, r_t is stock market return at time t.

BFGS method is used for the estimation of the parameters.

The transition probabilities are governed by markov two state process which are estimated as in equation (1.12). The parameters estimation in equations (1.13) and (1.14) supports the comparison of single-regime model with regime-switching model. Different level and sign of parameters in mean and variance of regime-switching stock market return model are assumed to reduce the forecast errors made on applying single-regime model.

3.2.5. Single-regime GARCH(1,1) model

Generalized Autoregressive Conditional Heteroscedasticity (GARCH) model of Bollerslev (1986) and Taylor (1986) has been popular model in different classes of asset returns modeling. The issues of volatility clustering in assets return are supposed to be better addressed by such models. The simplest form of GARCH model expressed below allows the conditional variance to be dependent on its own previous lags.

$$\sigma^2_t = \alpha_0+\alpha_1 u^2_{t-1}+\beta\sigma^2_{t-1}$$

where, σ_t is the conditional variance, u^2_{t-1} is the squared residual of the previous period and σ^2_{t-1} is the fitted variance of the model during the previous period.

The coefficients in the above equation have a chained or integrated interpretation about the volatility persistency in assets returns. Alexander (2004) describes that the large lag conditional variance coefficient, β, refers to high persistence of volatility meaning that shocks take long time to die out. The higher squared error coefficient (α_1) refers that the shock has immediate and intense reaction to the volatility.

Unlike ARCH model, the GARCH framework provides an easy and efficient estimation. The reason for this is the fact that the lag length selection and higher degree of possibility in breach of non-negativity constraint problems in ARCH models. GARCH model of lag 1 is more parsimonious just with three parameters in conditional variance equation which is an infinite order ARCH model (Brooks, 2008). The use of the GARCH(1,1) model (i.e. an ARMA(1,1) model for the conditional variance of the mean equation error term that is jointly estimated with the mean equation itself) is widespread as it generally sufficiently explains systematic variation of asset price volatility (Oberndorfer, 2009). Hence, for the purpose of this thesis, optimal lag order selection is kept salient in favour of standard GARCH (1,1) model. The specific single regime GARCH(1,1) framework implied in this thesis can be given as;

$$r_t = a_{01} + a_{02} r_{t-1} + u_t, \qquad u_t \sim N(0, h_t) \tag{1.15}$$

$$u_t = v_t\sqrt{h_t} \qquad v_t \sim N(0,1)$$

In eqn (1.15), the error term u_t is assumed to be conditionally heteroskedastic. Thus ARCH effect is assumed to determine the conditional variance of error terms obtained from mean equation. To accommodate the aggregate ARCH components effects, GARCH (1,1) components are used to define the conditional variance of error terms. The specification for conditional variance equation can be given as;

$$h_t = b_{01}+b_{11}u^2_{t-1}+b_{21}h_{t-1} \tag{1.16}$$

3.2.6. Regime-switching GARCH(1,1) model

Earlier in regime-switching AR(1) model, the variance of the error terms(alternatively variance of the stock market returns) during a particular regime was assumed to be constant. But assets price movements are often observed to exhibit volatility clustering. Because of this, a positive correlation between volatility and its level in immediate previous periods could be assumed. For instance of such characteristics, graph (figure 1) plotted for stock market returns of Singapore during 2001 to 2014 could be referred.

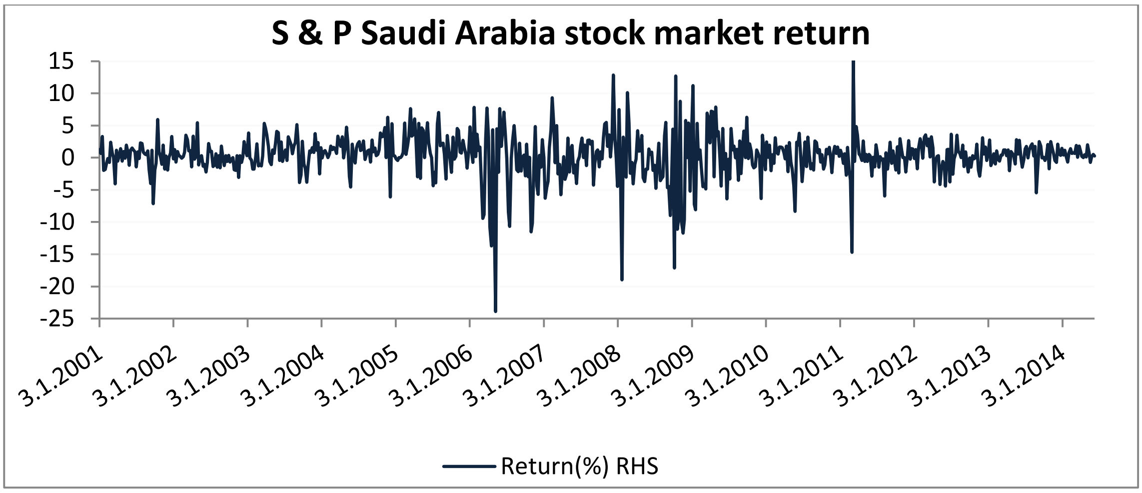

Figure 1. Saudi Arabia stock market index return

Hence, to address such volatility clustering including the possible leptokurtic distribution of assets returns and also the leverage effects, the use of volatility models in assets returns is crucial. In our two-regime framework, the similar behavior of stock market returns is assumed in each regime and the GARCH model is implied in both the regimes. The possible heteroscedasticity is assumed to be captured firstly by the switching nature of the model. Secondly, the within regime heteroscedasticity is assumed to be captured by the GARCH structure. Importantly, the symmetric influence of past equity return innovations are modeled in GARCH model. The model incorporates the lag squared residuals and lag conditional variance. In other words, both the components are the result of squares which cannot justify the probable asymmetric impact.

Regarding the switching volatility model development, Cai (1994) and Hamilton and Susmel (1994) both developed regime switching ARCH model with low-order ARCH process. With a solution to path dependence problem, Gray (1996) has developed switching GARCH model where the changes in short interest rate is modeled. This model is implied here for modeling stock market returns and is specified as follows.

$$r_t \mid \Phi_{t-1} \sim \begin{pmatrix} N(a01+a11rt-1,\ h1t) & \text{w.p.} & p1t \\ N(a02+a12rt-1,\ h2t) & \text{w.p.} & 1-p1t \end{pmatrix}$$

$$h_{1t} = b_{01}+b_{11}u^2_{t-1}+b_{21}h_{t-1} \tag{1.17}$$

$$h_{2t} = b_{02}+b_{12}u^2_{t-1}+b_{22}h_{t-1} \tag{1.18}$$

$$u_{t-1} = r_{t-1} – [\ p_{1t-1}\mu_{1t-1} + (1-p_{1t-1})\ \mu_{2t-1}\ ] \tag{1.19}$$

$$\mu_{1t-1} = a_{01} + a_{11}r_{t-2} \tag{1.20}$$

$$\mu_{2t-1} = a_{02} + a_{12}r_{t-2} \tag{1.21}$$

$$h_{t-1} = p_{1t-1}\ [\ \mu^2_{1t-1} - h_{1t-2}\ ] + (1 - p_{1t-1})\ [\ \mu^2_{2t-1} - h_{2t-2}\ ] – [\ p_{1t-1}\ \mu_{1t-1} - (1 - p_{1t-1})\ \mu_{2t-1}\ ]^2 \tag{1.22}$$

Specification for p_{1t} is displayed in eqn 1.12. Fixed transition probabilities are used to determine the switches between the regimes.

where, h_{1t} and h_{2t} are the variance of errors terms in regimes 1 and 2, respectively. μ_{1t} and μ_{2t} are the mean specifications in regimes 1 and 2, respectively. u_t and h_t are the error term and variance of the aggregate model, i.e. error term and variance of implied regime-switching GARCH (1,1) model.

3.2.7. Extended single-regime GARCH(1,1) model

Many literature have purposed the GARCH model with extensions, adding the most likely detrimental variables in mean and variance equations. These sort of multivariate GARCH model helps to link the impact of other variables on mean as well as volatility of dependent variable. For instance Arouri et al. (2012), Narayan and Sharma (2014), among others, have applied the extension on normal GARCH structure with additional variable(s). Aloui and Jammazi (2009) have used the Extended MS-EGARCH (1,1) with the additional Net Oil Price Increase (NOPI) variable in both the mean and variance equations of EGARCH structure. Gray (1996) also developed the Generalized regime-switching (GJR) model with the addition of interest rate level variable in the variance equation of MS-GARCH model.

For the purpose of assessment of oil price changes impact on stock market returns and returns volatility, we have augmented the GARCH(1,1) model. In the purposed model, the AR(1) variable is replaced by a lag oil price change variable in the mean equation. The variance equation is also extended with an additional cause variable (oil price changes) impact. The purposed Extended single-regime GARCH(1,1) model can be expressed as follows.

$$r_t = a_{01} + a_{02} r_{(oil)t-1} + u_{t,} \qquad u_{t,} \sim N(0, h_t) \tag{1.23}$$

$$u_{t,} = v_t \sqrt{h_t} \qquad v_t \sim N(0,1)$$

$$h_t = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1} + b_{31}\, r_{(oil)t-1} \tag{1.24}$$

where, $r_{(oil)}$ is a series of oil price changes. Rests of the variables are as usual as they appear before.

3.2.8. Extended regime-switching GARCH(1,1) model

Oil price impact on stock market returns during the specified two regimes is tested by the use of Extended regime-switching GARCH(1,1) model. The extension is similar to single-regime GARCH(1,1) model. Specifically, oil price changes are allowed to influence the stock market returns and stock market return volatility in each regime. Mathematical expression for the purposed model is as follows.

$$r_t \, \mathrm{I}\Phi_{t-1} \sim \begin{pmatrix} N(\mathrm{a01} + \mathrm{a11r}(oil)t-1,\ h1t) & \text{w.p.} \ \ p1t \\ N(\mathrm{a02} + \mathrm{a12r}(oil)t-1,\ h2t) & \text{w.p.} \ \ 1-p1\mathrm{t} \end{pmatrix}$$

$$h_{1t} = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1} + b_{31} r_{(oil)t-1} \tag{1.25}$$

$$h_{2t} = b_{02} + b_{12} u^2_{t-1} + b_{22} h_{t-1} + b_{32} r_{(oil)t-1} \tag{1.26}$$

$$u_{t-1} = r_{t-1} - [\, p_{1t-1} \mu_{1t-1} + (1 - p_{1t-1})\, \mu_{2t-1} \,] \tag{1.27}$$

$$\mu_{1t-1} = a_{01} + a_{11} r_{(oil)t-2} \tag{1.28}$$

$$\mu_{2t-1} = a_{02} + a_{12}\, r_{(oil)t-2} \tag{1.29}$$

$$h_{t-1} = p_{1t-1} [\, \mu^2_{1t-1} - h_{1t-2} \,] + (1 - p_{1t-1}) [\, \mu^2_{2t-1} - h_{2t-2} \,] - [\, p_{1t-1}\, \mu_{1t-1} - (1 - p_{1t-1})\, \mu_{2t-1} \,]^2 \tag{1.30}$$

Specification for p_{1t} is displayed in eqn 1.12. Fixed transition probabilities are used to determine the switches between the regimes.

where, h_{1t} and h_{2t} are the variance of errors terms in regimes 1 and 2, respectively. μ_{1t} and μ_{2t} are the mean specifications in regimes 1 and 2, respectively. u_t and h_t are the error term and conditional variance of the aggregate model, i.e. error term from mean equations and fitted variance of implied Extended regime-switching GARCH (1,1) model, respectively.

Hence the oil price role in shaping the stock market returns and volatility during two different regimes is assessed using this model.

3.3. Models Estimation Methods

The implied models in this thesis involve several estimations which include both the linear and non-linear estimations. All the linear relationships are estimated using Ordinary Least Square method whereas non- linear relationships are estimated by Maximum Likelihood method. Short discussion of these estimation techniques is presented below.

3.3.1. Ordinary Least Square method

Ordinary least square (OLS) method is widely used technique for parameters estimation of linear regression. A linear regression of the form $\hat{y}_t = \alpha + \beta x_t + \hat{u}_t$ is a straight line that runs between the data points of chosen variables y and x. u is a residual series, vertical distances from the fitted line to the actual data point. Thus a technique of minimizing these vertical distances would give a better fit of the data towards the constructed line. The method of OLS entails taking each vertical distance from the point to the line, squaring it and then minimizing the sum of squares (Brooks, 2008). For an expression of the method, let the residual sum of squares (RSS) be denoted by L. So,

$$L = \sum_{t=1}^{T}(y_t - \hat{y}_t)^2 = \sum_{t=1}^{T}(y_t - \alpha - \beta)$$

where, T is the number of observations, y_t is the actual data point and $\hat{y}_t$ is the fitted data point.

Now L is minimized with respect to α and β to obtain the line of closet fit to the data. Thus, through this procedure the coefficient estimators for α and β can be derived as follows;

$$\beta = \frac{\Sigma x_t y_t - T\bar{x}\bar{y}}{\Sigma x^2{}_t - T\bar{x}^2} \qquad \text{and} \qquad \alpha = \bar{y} - \beta\,\bar{x}$$

where, $\bar{x}$ and $\bar{y}$ are the averages (means) of dependent variable y and independent variable x, respectively.

Alongside, the OLS estimation process produces the standard errors as well as the level of significance of the estimates. The above mention estimation procedure is for simple linear regression models. Thus the 'single-regime constant mean and constant variance model' and the 'single-regime AR(1) model' in this thesis are estimated using OLS method.

4.3.2 Broyden-Fletcher-Goldfarb-Shanno method

For all the non-linear models applied here, Broyden-Fletcher-Goldfarb-Shanno (BFGS) method of function optimization is used to estimate the parameters. BFGS follows a quasi-Newtwon method for optimization of the specified function. The detail description of the function optimization and parameters derivation process would be beyond the scope of this thesis. Nevertheless, under the estimation procedure, different parameter values are obtained from each iteration and model seeks for optimal match of parameter values to the actual function. Importantly, for any convergence with iterations number less than the number of parameters, the parameters are poorly estimated and standard errors are likely to be incorrect (RATS UG, 2012). Thus, the estimation results are closely inspected to follow all the required criteria regarding the use of the estimation technique. All the regime switching models and single regime GARCH models are estimated using BFGS method.

4. DATA AND PRELIMINARY ANALYSIS

4.1. Data for Market Selection

Data for the analysis are obtained in two sections. This research focus on economies those are most likely affected by the oil price movements. Accordingly, first section of the data is collected to analyze countries level of dependency on oil trade. For this purpose, the level of dependency on oil is judged on the basis of net oil export as the percentage of GDP. To obtain the net oil export in dollars, first, net export of crude oil including lease condensate in thousand barrels per day was obtained from Energy Information Administration (EIA) for the years 2000 to 2010 in an annual basis. EIA have in total 224 countries in the list of net exporters of crude oil. Net oil export for the years later than 2010 was not available, though the mainstream analysis of the research accounts till 2014. Further, such collected data were converted to dollar values for the respective years. The rate for oil price was obtained as annual average rate in dollars per barrel form EIA (displayed in the table 1 below).

Table 1. Historical average annual price of oil per Barrel.

Euro Brent annual spot price (Dollars per Barrel)

Years	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Rate	28.66	24.46	24.99	28.85	38.26	54.57	65.16	72.44	96.94	61.74	79.61

Source: EIA

Now the net export of crude oil value per year for each country was obtained as;

Annual net export = spot rate per barrel × daily net export in barrels × 250

where, annual net export for each year corresponds to the respective year's spot rate. 250 trading days are assumed in a year.

Next, the annual GDP values in dollars for a list of 197 countries were obtained from World Bank in world development indicators data source available online. Few countries from the list of net exporter of crude oil but missing in the list of GDP were omitted. Hence, a total of 197 countries with their annual GDP in dollars and their respective net oil export values in dollars were finally obtained. Net oil export as the percentage of GDP per year was then calculated for each country as;

$$\text{Net oil- export (\%) of GDP per year} = \frac{Annual\ net\ oil\ export\ (dollars)}{Annual\ GDP\ (dollars)} \times 100$$

From the list of countries with annual net-oil export as a percentage of GDP, the countries were divided into two categories; net oil exporters and net oil importers. Countries with the negative annual net oil-export are the net importers. Later the average annual net-export as percentage of GDP was obtained for 10 years. From this list, the most likely countries to depend on oil-export or on oil-import were chosen.

Top ten countries in descending order of their average annual net oil-export as the percentage of GDP obtained by the above mention procedure are Equatorial Guinea, Angola, Congo (Brazzaville), Gabon, Oman, Saudi Arabia, Kuwait, Brunei, Nigeria and Qatar. Countries like Iran, UAE and Norway are also in the list of positive net oil exporters.

Similarly, top ten countries in descending order of their average annual net oil-import as the percentage of GDP are Bahrain, Belarus, Singapore, Lithuania, Jordan, Bulgaria, Thailand, Ukraine, South Korea, Macedonia and India. Belgium, Greece and Finland among others are also in the list of top countries in the basis of average annual net oil import as the percentage of GDP.

Market selection for the main stream analysis is based on the final list obtained above. Issues concerning the market efficiency and data availability have resulted the use of few countries as the target markets. As per the modeling of stock market returns as well as the analysis of oil price impact on stock market returns and volatility, two oil export dependent and one oil import dependent economies are selected. Saudi Arabia and Norway are net oil exporters and Singapore is the net oil importer since the period before our estimation period. This trend has been consistent throughout the period of 2001 to 2014 for all these target countries. A graph (figure 2) below presents the yearly net oil export as percentage of the respective GDP for these three countries.

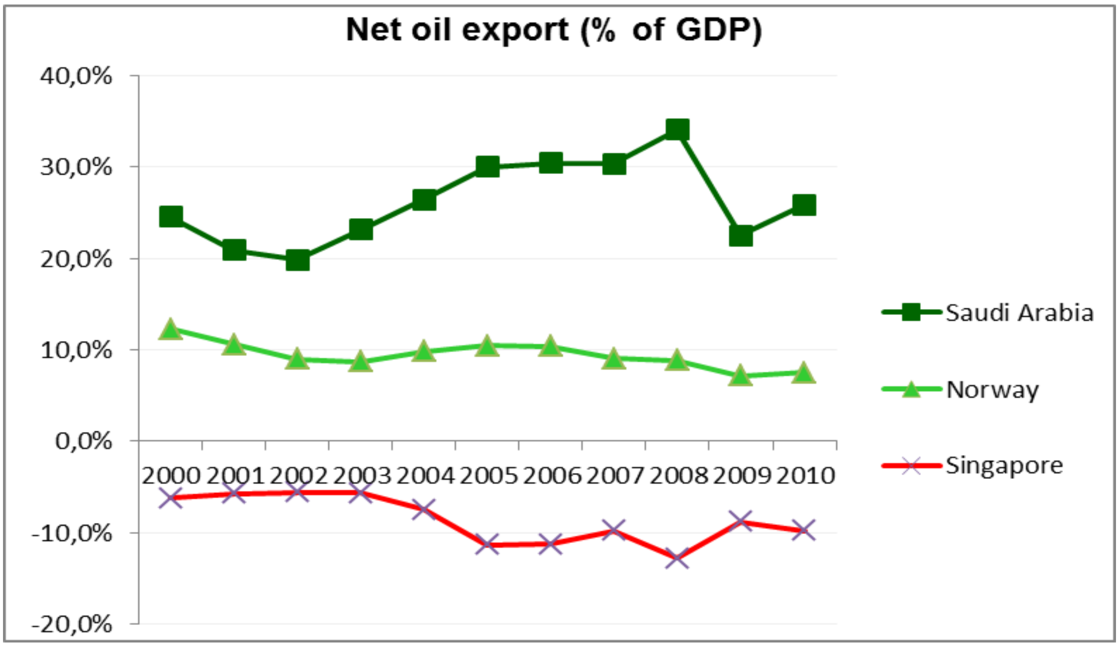

Figure 2. Net oil export (% of GDP) for oil export/import dependent target countries.

On the basis of above analysis, Saudi Arabia and Norway are considered to oil-export dependent economies. Similarly, Singapore is considered as the oil-import dependent economy. This consideration is based on the fact that GDP is the measure of the size of the economy composed of overall economic products of that country. Meanwhile if the net oil export or net oil import values reflect the significant portion of GDP, the economy is perceived to be more likely influenced by the movement in oil prices than do the other economies.

4.2. Data on Stock Markets and Oil Price

Both the analysis; stock market returns modeling and also the impact of oil price changes in stock market returns are limited to three of the target countries selected. Some of the other economies in the list of market selection criteria are rather appealing as target markets. But the final selection is based on availability of standard country stock market indices data throughout the estimation period. Accordingly, the weekly Wednesday to Wednesday data on stock market index prices (total return index) and oil price are obtained for the period of 27/12/2001 to 11/06/2014. Most often it is understood that the high frequency data, like daily or hourly data, reflect the noise problem in financial markets. Some empirical works like Andersen and Bollerslev (1998); Arouri and Nguyen (2010); among others, have argued that the high frequency data would lead to inaccurate forecasts in multivariate GARCH models. On the other hand, using monthly or quarterly data would lead to come up with insufficient observations for time series analysis. As well according to Aloui and Jammazi (2009) it is likely to detect the regime shifts clearly using low frequency data. They show preference using monthly or even lower frequency data. In contrast low frequency data may not provide persistency of regimes[7] which ultimately would not be encouraging in the use of switching model itself. Closing price (total return) of stock market index(s) on Wednesday is selected as the proxy for weekly data. One of the reasons is to minimize the day-of-the week effect. As well generally there are less holidays in Wednesdays compared to other days of the week which could avoid the non-synchronous trading day effects (Bhar and Nikolova, 2009; Henriques and Sadorsky, 2008; among others).

Selected estimation period from 2001 to 2014 covers both the economic stability as well as the troublance periods in the economies. Right after Asian crisis, economies had been improved around 2000. 2001 was followed by a terrorist attack in USA, which caused the US recession and had effect all over the globe. Period from 2003 to 2006 has been considered to be a global growth period reflecting the stable economic period. Since 2007, the global recession began affecting the economies around the world at least at some point till the end of 2011. Post 2011 period again is supposed as the period of economic recovery. The similar trend has been observed in oil price movement within this target period (more discussion on preliminary section below). Hence, the estimation period selected is well characterized by the periods of both economic growth and downturns which is a preliminary aspect for the use of switching models. Regarding the number of observations in volatility model estimation, a total of 703 weekly stock indices prices are obtained from DataStream. As the representation the country's economic indicator, MSCI standard country stock indices in US dollars are obtained for Norway and Singapore. In the case of Saudi Arabia, S&P Saudi Arabia index in US dollars is implied for the evaluation due to shorter period of data available as MSCI Saudi Arabia standard country index. Accordingly representing the Global oil price, the respective days Crude Oil-Brent Spot FOB U$/BBLwas obtained from DataStream. Since a common series of crude oil price is used in case of all the countries, the series of stock market indices in a common currency denomination would be appealing. In addition the impact of exchange rate changes is itself incorporated within the obtained stock index prices on using the prices

[7] Comparatively the lower return regimes (recession periods) in the stock market are likely to be shorter than the higher return regimes (stable growth periods). In turn, the estimation of parameters for shorter regimes would lack enough observations due to low frequency data employed.

denominated in a common currency. Total return index series were obtained for stock index prices which consider that the dividends are reinvested at the existing rate of return. Thus price covers both the dividend and capital gains (for instance see Henry, 2009). To avoid the possible non-stationarity in the series under analysis, country stock index returns are modelled rather than the prices. The simple returns on stock indices are obtained as;

$$r_t = \frac{Pt - Pt{-}1}{Pt{-}1} \times 100$$

where, r_t is weekly rate of return on stock index at time t, P_t is stock index value at time t and P_{t-1} is stock index value at the consecutive previous time period (i.e. t-1).

Similarly, global oil price variable is too converted into percentage change in oil price relative to the consecutive previous time period. This can be given as

$$r_{(oil)t} = \frac{P(oil)t - P(oil)t{-}1}{P(oil)t{-}1} \times 100$$

where, $r_{(oil)t}$ is the weekly percentage change in oil price at time t, $P_{(oil)t}$ is the oil price at time t and $P_{(oil)t-1}$ is the oil price at the consecutive previous time period (i.e. t-1).

Finally a total of 702 observations on stock indices returns and oil price changes are applied for the analysis for the period of 03/01/2001 to 11/06/2014.

4.3. Stock Markets Performance

In this section some simple graphics analysis is made on the stock indices returns. A similar analytic discussion on oil price movement is followed. Specifically in stock market indices values and returns, the trends on movement and their probable cause are intended to sort out. Graphs below (figure 3, 4 and 5) are the time line plots for the stock indices price and returns for the three target countries.

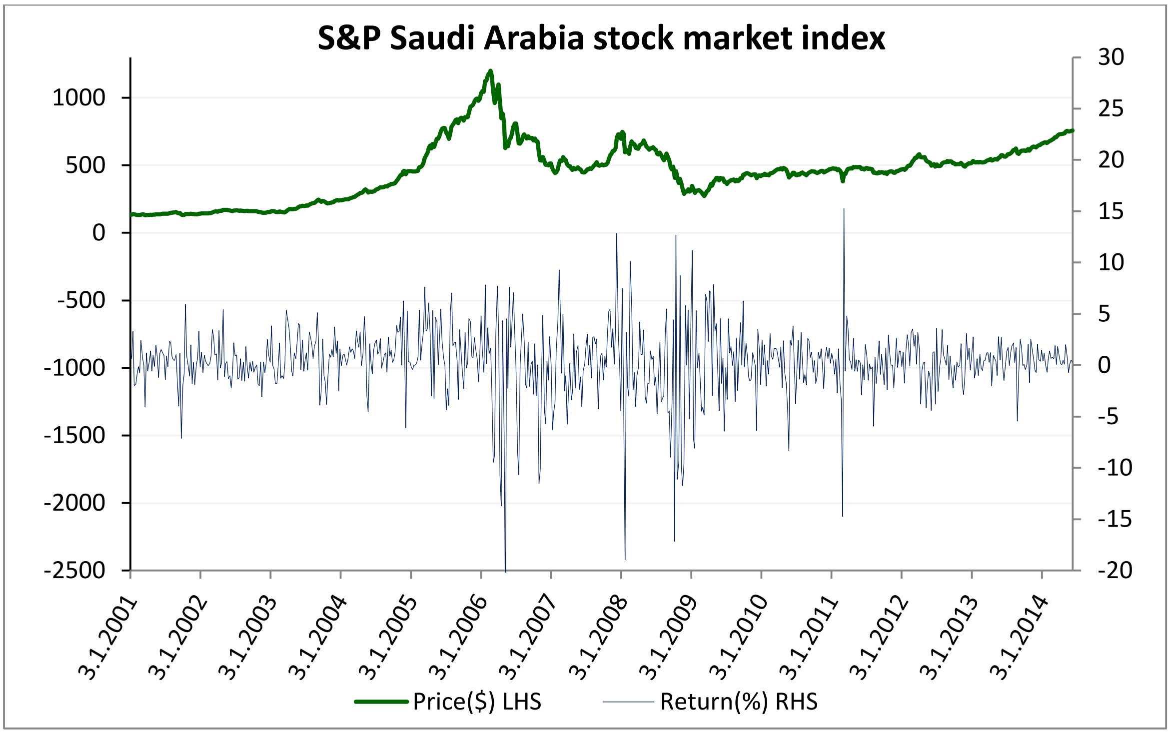

Figure 3. Saudi Arabia stock market index value and return.

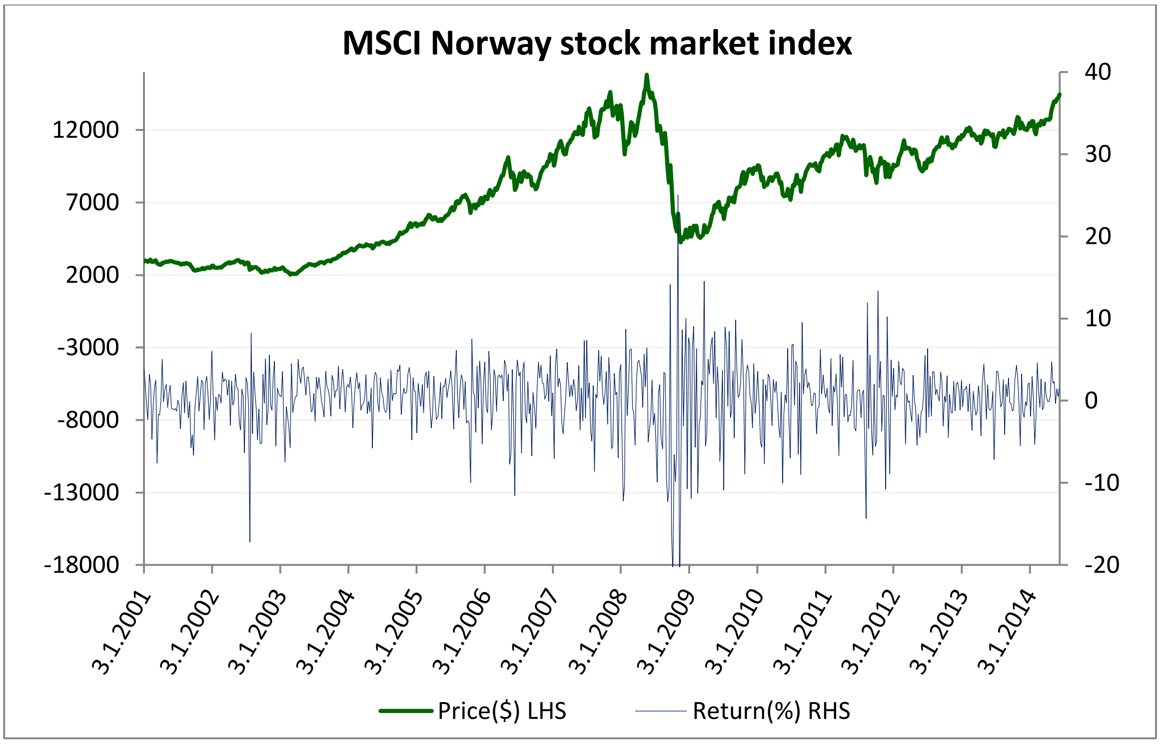

Figure 4. Norway stock market index value and return.

Saudi Arabia and Norway both have simultaneously occurring different economic regimes within the estimation period of 2001 to 2014. The price development curves above (figures 3 and 4) show that constant growth rate during 2001 to around 2003 was preceded by the rapid growth rate from 2004 for both the countries. Saudi Arabia stock market index price reached a pick of around 1200 dollars by the end of 2005. From March 2006, Saudi Arabia fell a long recession with a sign of improvement around the end of 2007. Again an episode of stock market downfall occurred from early 2008 lasting around a year. The stock index price development after 2009 in Saudi Arabia seems stable with long rising trend till the end of the estimation period. On the other hand Norway stock index performed well with several rapid growths for the period of 2004 to end of 2007. Nevertheless this period suffered some short crashes in between. 2008 remained the most degrading year for Norway stock market investors as the price dropped rapidly. The period from the end of 2008 till the end of estimation period looks in average a growth period. Though some crashes occurred at least once in each of the years 2010, 2011 and 2012, they were not of high loss of value as of 2008.

Overall, both these oil-export dependent economies faced stable and unstable economic periods in turn during the estimation period. Such regimes in economies look reoccurring with the passage of time. Importantly, both the regimes (stable and unstable) tend to be persistent as they last for several weeks and even for more than a year. Comparatively, Norway stock market has faster recovery of any crashes as the downward price movements are sooner followed by the upward movements. This would mean that the unstable regime (recession) would be less persistent in the case of Norway stock market than that of Saudi Arabia.

Stock market returns plotted on the RHS (right hand side) of the graphs present the nature of stock market volatility. During the stable and consistent period in stock market price development, the return volatility looks stable too. Normally, the market seems less volatile during stable economic periods. In the case of Saudi Arabia, such periods like, 2001 to 2005 and 2011 to 2014 are much distinctly visible from the graph (figure 4). In contrast the recession regimes correspond to high volatility for both the economies. Much striking phenomenon in the graphs seems to be low volatility followed by low volatility and vice versa. So the preliminary assessment of volatility of the stock market returns looks happening in clusters. Thus, a volatility model, for instance ARCH or GARCH, would better explain the information contained in such clusters.

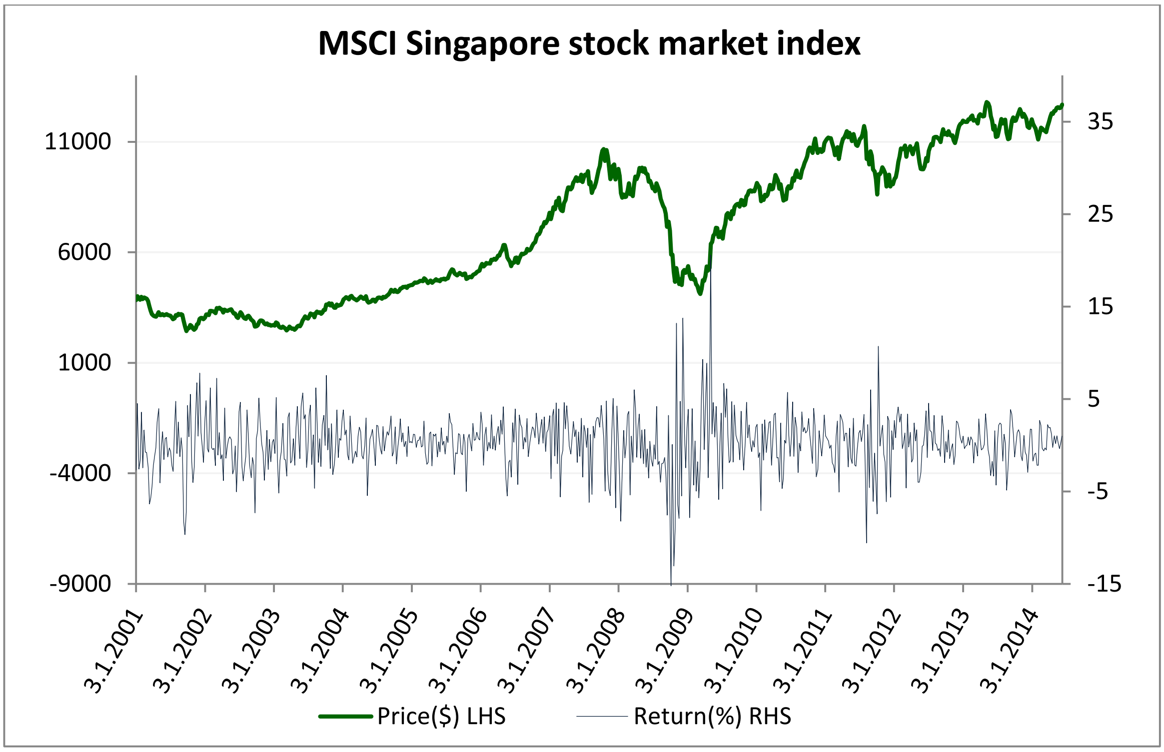

Figure 5. Singapore stock market index value and return.

Singapore, the target oil import dependent economy, also has suffered several economic phases within the estimation period. Period from the end of 2007 to first quarter of 2009 has the steeper fall in stock market index value (figure 5). Another notable crash could be seen during the second half of 2011. Coinciding with the oil export dependent economies, volatility pooling effect is visible in Singapore stock market too through the return graph.

Regarding the recession on 2009, all the three target countries have lost their stock market index values. This period coincides with the rapid fall in oil price. As the oil export dependent economy, Saudi Arabia stock market index price has responded almost all the visible changes in oil prices. For example oil price drops in 2006 and 2008 are followed by the drop in stock index value. On the basis of such characteristics observed in stock market indices value and return, the mainstream analysis uses the suitable models to make statistical inference followed by the economic interpretations.

4.4. Oil Price Movements

US oil production companies had a control over oil price before 1973. Once the Yom Kippur war broke, price of oil as other commodities started to be settled as per the equilibrium of demand and supply (Driesprong et al., 2008). Since then it has followed a long moment with several shocks, both ups and downs. Estimation period for this thesis starts right after the Asian crisis which also had affected the oil price variability. Till then oil price was somehow affected by wars and conflicts among the producers, exporters and importers (Hamilton, 2011a). The resumed growth period of 1999 to 2000 helped to overcome the oil price dropped during the Asian crisis. By March 2001, the U.S. recession began and the price was again dropped down. From November 2002 to February 2003 a pick on oil price was observed due to production cut off in Venezuela and Iran. The events behind this were Venezuelan unrest and the second Persian Gulf War. According to Hamilton (2011a), the growing global growth and development in 2004 to 2005 created high demand to raise the oil price upward. Later, in 2005, the oil price shock was associated with the unrest in two giant exporters Nigeria and Iraq. The historical peak of shock from 2005 to 2008 would be the result of high rise in global oil demand and limited supply. This surge was caused by unexpected increases in world oil consumption driven by the global business cycle (Kilian and Murphy, 2010). Along with this explanation, the speculative dollars investment into oil and commodities market as a reason for drastic oil price movement between 2005 and 2008 has got enough space in recent researches. The US recession from the early 2008 affected the price level to drop down again. The most recent phase of the oil price movement has in average recovered the previous average price level with the slow recovery of the global recession after 2009. A trend line associated with this oil price movement during the estimation period is presented below (figure 6).

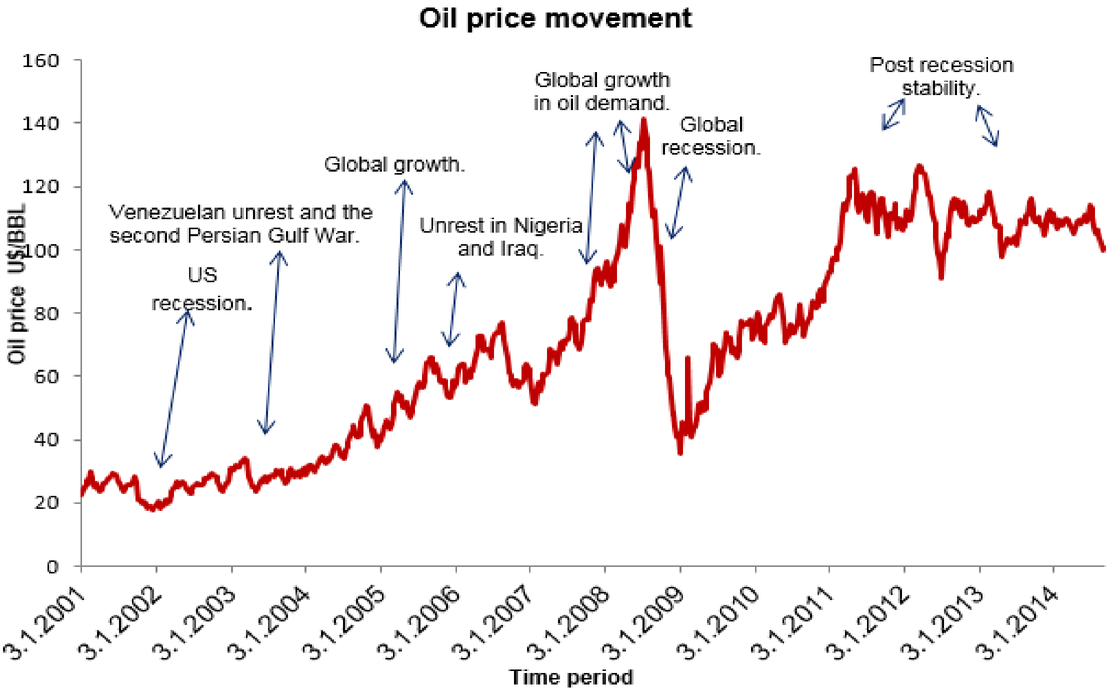

Figure 6. Oil price movement and associated events.

From the history of oil price movement, it appears that the price of oil is settled as equilibrium during stable economic situation. Rising demand and supply cut off lead to rise in price level whereas the reduced demand curtails the price level of oil. Beside this phenomenon, various political and economic factors play the key role. Historically, the big shocks in oil price are coincided with the periods of conflict among the producers, the unionized control of the exporters, the continental and the global recessions, the financialiazation of commodity market and the rapid economic growths. These sort of political and economic happenings suddenly affect the level of demand and supply of oil which ultimately changes the price.

4.5. Measurement of Oil Price Change

Measurement procedure of change in oil price is crucial on analyzing its relationship with other variables. Study on oil price shocks measurement has a long history. Initially, Hamilton (1983) has used a linear specification to measure the oil price changes. In his paper, oil price change; specifically oil price shock, is the log difference of the nominal price levels. In econometrics, log differencing has been one of the popular method for the measurement of rate of change. Since then many literature related to oil price, (for example Cunando and Perez (2003); Driesprong et al. (2008); among others) have implied linear specification of log differencing to obtain the oil price shock. Mathematically,

$$\Delta P = \log(P_t) - \log(P_{(t-1)})$$

The analysis of oil price impact in economy grew once Hamilton (1983) pioneered the oil price as a variable into economics. Later, Mork (1989) reviewed the Hamilton research and treated oil price shock as two different specification. Significant results were obtained on specifying the oil shock variable as oil price increases and oil price decreases. Overall, the result characterized the oil price shock to be affecting asymmetrically. Recently the oil price shocks are specified in various specifications.

The one that has drawn the researchers attention is scaled oil price (SOP) introduced first by Lee et al. (1995) and later extended by Park and Ratti (2008). Lee et al. (1995) argue that the oil shock impact is more in environment with stable oil price than in environment where the price has been more frequent and erratic. In their paper, the oil price shock has been specified by the Generalized Autoregressive Conditional Heteroscedasticity (GARCH) (1,1) model as;

$$\mathrm{op}_t = \alpha + \sum_{i=0}^{p} \alpha_i op_{t-i} + \sum_{i=0}^{q} \beta_i z_{t-i} + \varepsilon_t, \quad \varepsilon_t | I_{t-1} \sim N(0, h_t), h_t = \gamma_0 + \gamma_2 \varepsilon_{t-1}^2 + \gamma_2 h_{t-1},$$

where, op_t is first log difference in real oil price, ε_t is an error term, and $\{z_t - 1 : I \geq 1\}$ denotes an appropriately chosen vector contained in information set I_{t-1}. The lags p and q are selected optimally.

Later extended, scaled oil price (SOP) by Park and Ratti (2008) can be defined as:

$$SOP_t = \frac{\varepsilon t}{\sqrt{ht}}$$

Another popular specification for oil shock by Hamilton (1996) is net oil price increase (NOPI). He argues for appropriate measure of impact of oil price changes, the current oil price must be compared to past 4 quarters. This is due the fact that the upward shocks are often reversed by bigger downward shocks. Being more specific, Hamilton (1996) defines NOPI as the maximum of zero and the percentage difference in the value of the current quarter from the maximum value achieved during the previous four quarters. It can be expressed as:

$$NOPI_t = \max(0, \log P_t - \max(\log P_{t-1} \ldots \log P_{t-4})$$

where, $\log P_t$ is the log of level of real oil price at time t.

Later, in Hamilton (2003), the current oil price comparison criterion was extended from past 4 quarters to past 12 quarters.

Kilian and Park (2009) have further classified the oil price shocks as ‘oil supply shocks’, ‘aggregate demand shocks’ and ‘oil market specific demand shocks’. This classification has been defined according the nature of cause behind the shock. The shocks to global supply of crude oil are defined as oil supply shock. Shocks driven by real economic activity affecting the demand for all the industrial commodities including the crude oil are classified as ‘aggregate demand shock’. Whereas, the shocks due to the shift in demand of crude oil with an uncertainty in future supply of oil is classified as ’oil specific demand shock’. Finally, these classifications of shocks are used separately to test the effects of oil price changes on stock market returns. A recent study Aastveit (2014) has also implied similar categorization oil price shocks.

For the simplicity, the analysis in this thesis is based on simple percentage change in oil price with respect the earlier period oil price. The log differencing in nominal oil price would be another choice. Classification of change in oil price is kept salient due to the fact that mainstream analysis focuses on aggregate oil price shock impact on stock market performance and risk.

4.6. Descriptive Statistics

For the purpose of understanding the basic characteristics of the data under analysis, normal statistics figures and calculations are presented in this section. Descriptive statistics of the return series along with the oil price changes variable are presented in table 2. Representing a long term average return on stock markets, mean and median are displayed for each series. Alongside average long term risk is represented by standard deviation. Statistics shows that overall return and risk on Singapore stock market is lower than that in other two target oil-exporting countries.

Nature of the distribution of series is explained by the Bera-Jarque test. This test uses the property of a normally distributed random variable that entire distribution is characterized by the first two moments –the mean and the variance (Brooks, 2008). Skewness and Kurtosis, the standardized third and fourth moments, measure the extent of the distribution not to be symmetric to the mean value and fatness of the tails of the distribution, respectively. The distribution of a normally distributed series is not skewed and has the coefficient of kurtosis equal to 3. Significant Jarque-Bera statistics on all these time series along with the varied parameters of skewness and kurtosis reflect at least some degree of leptokurtic distribution. Most notably coefficients of kurtosis for all four series are highly greater than 3. It is visible through the histograms (Appendix 1) that all the variables are peaked at the mean and have fatter tails. In line with description on Brooks (2008), these financial time series have leptokurtic distributions. For estimation using the OLS technique, normal distribution is assumed to hold on the series. It would therefore require some shuffling of the contents within the series to imply at least the near normality. In financial modeling, most often the extreme outlier observations are removed to improve the chances of normality. As the mainstream analysis focuses on the volatility

Table 2. Descriptive statistics on stock market index returns and oil price changes.

	Norway rstk.(%)	*Saudi Arabia rstk.(%)*	*Singapore rstk.(%)*	*Oil price change roil.(%)*
No.Obs.	702	702	702	702
Mean	0.32	0.31	0.21	0.32
Median	0.72	0.48	0.32	0.45
Standard deviation	4.24	3.46	3.08	4.56
Skewness	-0.66	-1.22	0.08	1.06
Kurtosis	8.19	10.66	7.96	25.16
Jarque-Bera	840***	1889***	720***	14494***
Correlation coeff.				
roil (%)	0.05	0.10	0.04	1.00
roil(%) lag 1	0.39	0.18	0.25	0.09
Autocorrelation coeff.				
lag 1	-0.083**	0.077**	0.043	0.087**
lag 2	-0.065**	0.016	0.020	-0.058**
lag 5	0.038***	0.044*	0.041	-0.042***
ARCH-LM test coeff.				
Sq.resid. lag 1	0.401***	0.199***	0.031	0.365***
Sq. resid. lag 2	-0.032	0.007	0.174***	-0.067
Sq. resid. lag 5	0.206***	0.033	0.056	-0.039
ADF test statistic	-14.539	-24.483	-25.328	-24.248
KPSS test statistic	0.059	0.219	0.076	0.055

***,** & * represent significance at 1%, 5% & 10% level respectively.

model, using maximum likelihood estimation technique, the observations are implied originally without any modifications or omissions. In other words, the leptokurtic distributions are most likely the representation of the volatility pooling within the variable series. Thus the GARCH type of models would capture such characteristics.

Positive correlation coefficients (table 2, panel 2) between stock market returns and oil price changes is natural for oil-exporting countries. It is more important that the correlations between lagged oil price changes and stock returns are all positive and higher in magnitude. Such a bond between these series encourages for further analysis of possible relationship between stock market innovations and oil price changes. Doubtfully long run correlation between Singapore stock market return and lagged oil price changes is positive. Though such a statistics do not support our hypothesis in case of oil-importing countries, the implied economic-regime dependent relationship structure seeks to address the precise linkage.

Preliminary analysis of autocorrelation coefficients would be essential in univariate analysis methods. Significant autocorrelation coefficients (Table 2, panel 3) obtained on all series[8] supports the adequacy of implied single-regime and regime-switching AR(1) models. In addition, initial test of ARCH effect before applying any GARCH family model is considered vital in econometrics. Widely implied ARCH-LM test has been used to detect existence of serial auto correlation in squared residuals. In table 2, panel 4 presents statistically significant autocorrelation coefficients in squared residuals for all the stock market return series under consideration. These coefficients also reflect the leptokurtic distribution of stock market return series. Hence, the purposed Extended regime-switching GARCH model makes a better fit to the nature of distribution in exogenous variables.

Stationary in data is an essential requirement in time series modeling. In the meantime, Brooks, (2008) argues particularly in many financial time series the possibility of unit root persists. To avoid the case of non-stationarity in a series, commonly first differencing is implied. In the case of stock market index prices and oil price series, the first differencing is applied on obtaining the stock market returns and oil price changes. Despite this a non-stationarity test is essential as use of non-stationary series in a system would lead for spurious regression. For the further confirmation of stationarity in return and oil price change series, both the non-stationarity and unit root tests have been implied. Table 2 in panel 5 presents Augmented Dickey-Fuller (ADF) test statistics for unit root test and Kwiatkowski-Phillips-Schmidt-Shinteststatistic (KPSS) test statistics for the non-stationary test in all the series under consideration. Based on both these tests[9], all the series of stock market returns and oil price changes are free of unit root or non-stationarity. Hence application of these data on financial modeling produces robust estimates.

Preliminary analysis was conducted to understand and check the basic characteristics of the data under analysis and underlying assumptions for the model applied in the mainstream analysis. The following section continues with the model estimations and analysis of the obtained results.

[8] Unreported autocorrelation coefficients at lags 3, 8, 10 and 11 on Singapore stock market return series are statistically significant at 10% level.

[9] See Appendix 2 for the further analysis and critical values of test statistics from both non stationarity tests.

5. EMPIRICAL RESULTS

This section includes the presentation of the model estimation results. All the research questions are analyzed, modelled with empirical methods and tests results are interpreted in arguments for rejection or in favor of the purposed research quests. All the models applied to obtain the results in this section are presented above in the empirical framework section. This section presents the analysis of the results, their statistical significance and economic significance in chronological order of the designed research questions.

For analysis on oil export or import dependent economies, Saudi Arabia is selected for analysis representing the oil export dependent economies and Singapore for the analysis of oil import dependent economies. Meanwhile, estimated result on Norway stock market is also displayed which is fairly close to the characteristics of results obtained for Saudi Arabia. Results on Norway stock market index return series are incorporated in order to make the results and interpretation more realistic and to confirm any insignificant results obtained for Saudi Arabia.

5.1. Result of Mean Models

To begin the estimation, first the single-regime constant variance model was implied. Parameter estimates for single-regime constant variance model are displayed in table 3, second, third and fourth columns. As shown in the table, the constant mean parameters for both the countries stock market return are statistically significantly different from zero. In long term, weekly mean return from Saudi Arabia stock market index is 0.31%.This is higher than that of Singapore stock market index return though returns on both the stock market indices are positive. This result is common reflecting return on investments phenomenon in long term perspective.

Critical analysis is made on the assumption of homosedasticity (a constant variance of the error terms) in the implied model. Accordingly, second panel of table 3 in second, third and fourth columns reports the Ljung-Box (LB) statistics for standardized squared errors[10] of single-regime constant variance model. The test statistics suggests a serial correlation

[10] Standardized squared residuals are the square of the ratio of error terms divided by the square root of errors variance.

in squared standardized error terms. LB statistics are clearly high and significant. Thus, this result suggests for a model that accounts for heteroscedasticity in residuals.

Table 3. Estimates of constant mean and constant variance models.

Sample (03/01/2001 to 11/06/2014) of weekly stock market index return, r_t, is under specification. In single-regime constant mean and constant variance model; $r_t \mid \Phi_t \sim N(a_{01}, b_{01})$.

In regime-switching constant mean and constant variance model; $r_t \mid \Phi_t \sim \begin{pmatrix} N(a01,\ b01) & \text{w.p.} & pt \\ N(a02,\ b02) & \text{w.p.} & 1-pt \end{pmatrix}$, where p_t and $1-p_t$ are the probabilities of economic state being in regime-1 and regime-2, respectively.

	Constant mean and variance model					
	Estimate (Single-regime)			Estimate (Regime-switching)		
Coeff.	*Saudi Arabia*	*Norway*	*Singapore*	*Saudi Arabia*	*Norway*	*Singapore*
a_{01}	0,31***	0,33***	0,21***	0,48***	0,58***	0,34***
a_{02}				-0,21	-0,56	-0,44
b_{01}				1,86***	2,74***	2,30***
b_{02}				6,07***	7,24***	5,69***
p(1,1)				0,98***	0,98***	0,99***
p(2,2)				0,93***	0,94***	0,94***
Ljung-Box statistics of squared standardized residuals						
LB^2_1	49,13***	164,89***	10,88***	3,69**	2,90**	0,07
LB^2_2	63,26***	206,14***	49,84***	3,74	2,90	0,96
LB^2_3	121,57***	230,14***	84,36***	4,47	3,11	7,02**
LB^2_4	152,32***	292,83***	106,65***	5,35	6,43	7,07*
LB^2_5	164,34***	396,78***	122,98***	5,36	6,63	8,48*
LB^2_{10}	239,45***	586,22***	201,16***	16,06**	11,98	22,69*
LB^2_{15}	254,39***	635,86***	211,45***	18,57	18,04	25,26***

***, ** & * Significance at 5%, 10% & 15% levels respectively. LB^2_i represents the Ljung-Box statistics of squared standardized residuals at lag i.

Single-regime constant mean and variance model was implied for a long estimation period of 2001 to 2014. This period was characterized by many upwards and downwards movements in stock market indices. Periods of recession and normal growth occurred in turn and reoccurred within this estimation period. Thus, an assessment of a regime-switching constant variance model is followed. This model assumes a constant variance in particular regime but different variances in different regimes. Literally, any conditional heteroscedasticity is assumed to be controlled by the switching between the regimes.

Thus, parameter estimates of regime-switching constant variance model for all three target countries are presented in table 3 on fifth, sixth and seventh columns. As it appears in the result, both the regimes have high persistency, indicated by p(1,1) and p(2,2), in case of all the countries stock market index return models. In two regimes structure, the mean returns; a_{01} and a_{02} as well as the standard deviations; b_{01} and b_{02} are different in magnitudes. In both the stock index returns, regime-1 has statistically significant higher mean than in regime-2. It is noteworthy that regime-2 weekly mean return is negative though it is not statistically significant. The single-regime mean return lies in between these two conditional means of regime-switching model. This is an evidence of precision of regime switching model. In contrast to the conditional means, the conditional variance is higher in regime-2 than in regime-1. Collectively, regime-1 is characterized as high mean return and low variance regime whereas regime-2 is characterized as low mean return and high variance regime in both the countries.

LB statistics for standardized residuals from regime-switching constant variance model are far reduced compared to that of single-regime constant variance model. In fact the LB statistics figures of regime-switching model are mostly insignificant suggesting the high reduction of serial correlation in residuals. Fairly the regime-switching mean model has overcome the most part of heteroscedasticity problem in single-regime mean model.

Table 4. Estimates of AR(1) with constant variance models.

Sample (03/01/2001 to 11/06/2014) of weekly stock market index return, r_t, is under specification.

In single-regime AR(1) with constant variance model; $r_t|\Phi_{t-1} \sim N(a_{01}+a_{11}r_{t-1}, b_{01})$.

In regime-switching AR(1) with constant variance model;

$$r_t|\Phi_{t-1} \sim \begin{pmatrix} N(a01+a11rt-1,\ b01) & \text{w.p.}\ pt \\ N(a02+a12rt-1,\ b02) & \text{w.p.}\ 1-pt \end{pmatrix}$$

where, p_t and $1-p_t$ are the probabilities of economic state being in regime-1 and regime-2, respectively.

	AR(1) model with constant variance					
	Estimate (Single-regime)			Estimate (Regime-switching)		
Coefficient	Saudi Arabia	Norway	Singapore	Saudi Arabia	Norway	Singapore
a_{01}	0,28***	0,35***	0,21**	0,44***	-0,66	-0,38
a_{02}				-0,23	0,59***	0,31***
a_{11}	0,08	-0,08	0,04	0,10***	-0,15**	0,03
a_{12}				0,06	0,00	0,04
b_{01}				1,86***	7,14***	5,71***
b_{02}				6,11***	2,74***	2,3***
p(1,1)				0,98***	0,94***	0,94***
p(2,2)				0,93***	0,98***	0,99***

*** & ** Significance at 5% & 10% levels respectively

For further confirmation of the results, the constant mean was replaced by the standard AR(1) structure in constant mean and constant variance model applied before. The results of single-regime AR (1) model and regime-switching AR (1) model for all the target markets are presented in table 4. These coefficient estimates and their significance are in line to that of constant mean and constant variance model. The only visible change is seen in two regime structure of regime-switching AR (1) model for Norway and Singapore. But these changes are merely the interchange of the regimes meaning that the regime-1 characteristics in regime-switching constant mean and constant variance model are moved to regime-2 in regime-switching AR(1) model and vice versa. All the remaining features coincide with the results of regime-switching constant variance model. Hence, it would not require for any further explanation.

To closely identify the regimes obtained from the above results, figures 7 and 8 present the graph plots of Saudi Arabia and Singapore stock markets indices, smoothed probabilities along with the ex-ante probabilities of regime-1 and corresponding conditional standard deviations. The variable plots are in accordance to the estimation of constant mean and constant variance model.

From the graph it is detectable that when the probabilities of regime-1 is higher (close to one), the corresponding index price is trending upwards (high index returns) and the same time conditional standard deviation is lower (low volatility). Just opposite to it, during regime-2, meaning that probabilities of regime-1 close to zero, the corresponding index price is trending downwards (low index returns) and the same time conditional standard deviation is higher (high volatility). Hence regime-1 corresponds to high mean returns and low volatility which is fairly the stable economic growth period. For instance, such a stable period can be observed in between 2004 to 2006, 2010 to 2011 and 2012 to 2014 in case of Singapore stock market. In contrast, period of recessions and downturns is reflected by regime-2, where there is low mean returns and high volatility. Periods in between 2007 to 2008, 2008 to 2009 and 2011 to 2012 corresponds to unstable economic growth periods in Singapore.

1. *These results provide evidence in favor of the first research question. Long term stock market movement in oil-importing and oil-exporting target countries incorporate two distinct regimes with different level of return and risk.*

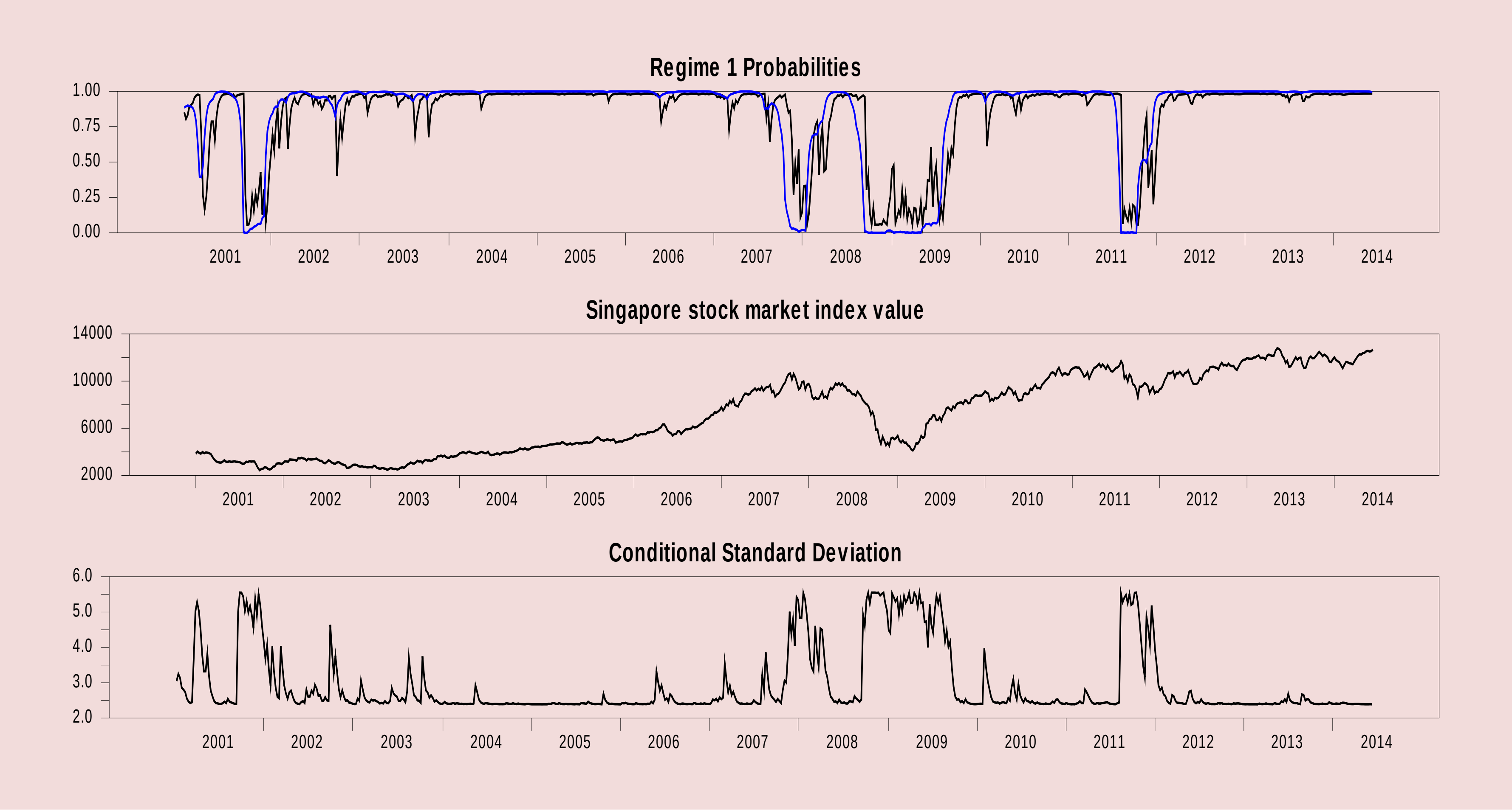

Figure 7. Regimes Characteristics in Singapore stock market.

Dark and blue lines in the first panel represent the regime-1 ex-ante and smoothed probabilities.
Panel 3 plots the conditional standard deviation obtained from the overall model throughout the estimation period.

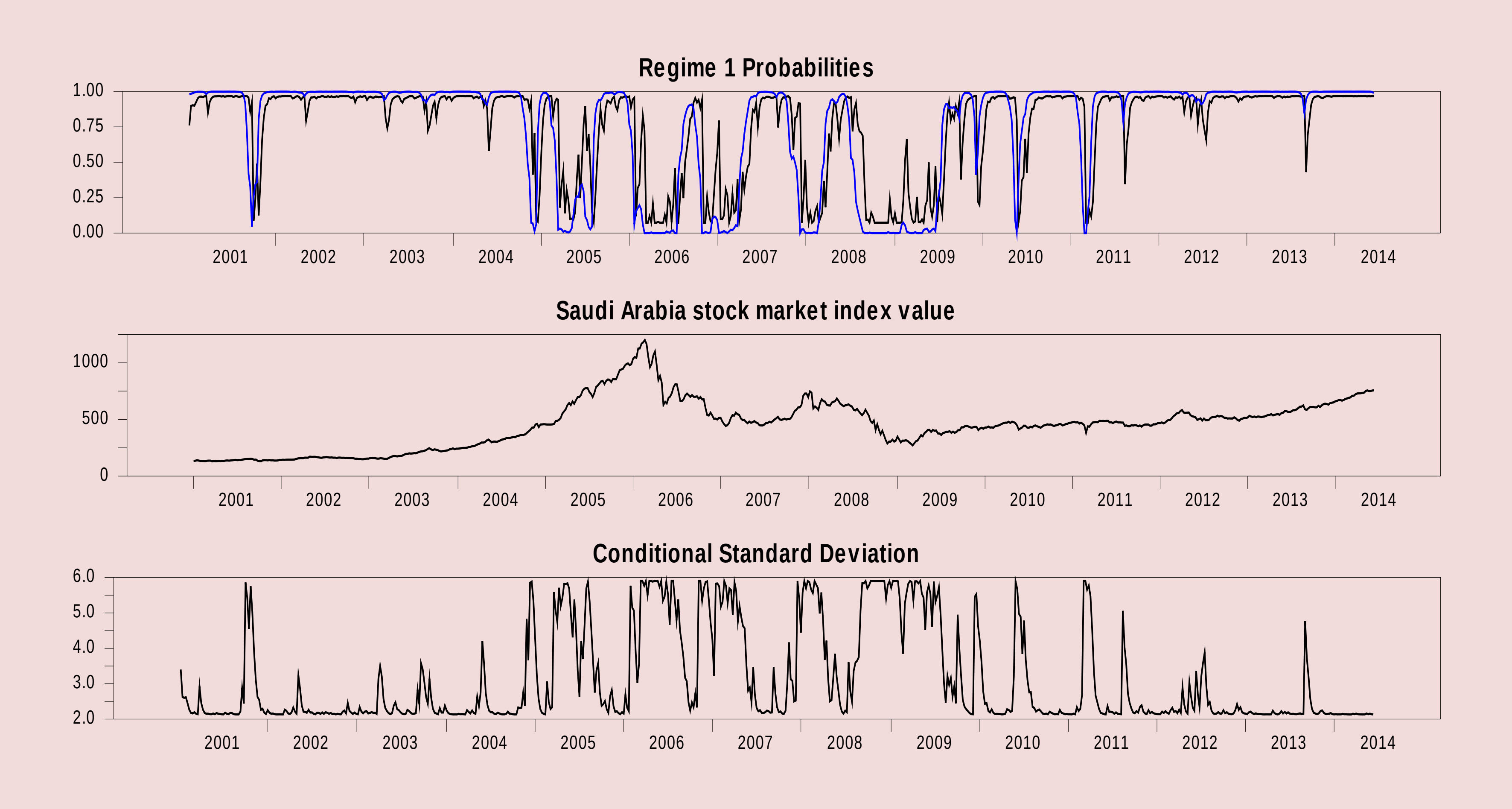

Figure 8. Regimes Characteristics in Saudi Arabia stock market.

Dark and blue lines in the first panel represent the regime-1 ex-ante and smoothed probabilities.
Panel 3 plots the conditional standard deviation obtained from the overall model throughout the estimation period.

5.2. Result of Volatility Models

5.2.1. Results of single-regime and regime-switching GARCH (1,1) model

Though the residuals correlation was highly reduced in regime-switching constant variance models, it is common that financial asset returns are featured by the volatility pooling. To some extent, some of the lagged residuals are still found serially correlated significantly through Ljung-Box tests. Thus, the residuals are the matter of assessment for any role in determining the asset return dynamics. Accordingly, the within regime constant variance is relaxed in favor of variance modeling. Thus a GARCH procedure is applied on variance of each regime. Table 5 below presents the results of single-regime as well as the regime-switching GARCH(1,1) model on all the target economies under evaluation.

Table 5. Estimates of GARCH(1,1) models.

Sample (03/01/2001 to 11/06/2014) of weekly stock market index return, r_t, is under specification.

In single-regime GARCH(1,1) model;

$r_t = a_{01} + a_{02} r_{t-1} + u_t$, where $u_t \sim N(0,h_t)$, $u_t = v_t\sqrt{h_t}$ and $v_t \sim N(0,1)$. Also, $h_t = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1}$

In regime-switching GARCH(1,1) model;

$r_t \mid \Phi_{t-1} \sim \begin{pmatrix} N(a01+a11rt-1,\ h1t) & \text{w.p.} & p1t \\ N(a02+a12rt-1,\ h2t) & \text{w.p.} & 1-p1t \end{pmatrix}$, $h_{1t} = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1}$ and $h_{2t} = b_{02} + b_{12} u^2_{t-1} + b_{22} h_{t-1}$, where p_t and $1-p_t$ are the probabilities of economic state being in regime-1 and regime-2, respectively.

	GARCH(1,1) model					
	Estimate (Single-regime)			Estimate (Regime-switching)		
Coefficient	*Saudi Arabia*	*Norway*	*Singapore*	*Saudi Arabia*	*Norway*	*Singapore*
a_{01}	0,41 ***	0,46 ***	0,28 ***	0,42 ***	0,68 ***	0,27 ***
a_{02}				0,58 ***	-0,50	0,23
a_{11}	0,13	-0,02	0,08 ***	0,12 ***	-0,11 ***	-0,02
a_{12}				-0,02	0,12	0,80 ***
b_{01}	0,50 ***	0,72 ***	0,18 **	-0,09	-0,17	0,56 ***
b_{11}	0,29 ***	0,15 ***	0,13 ***	0,05 *	0,01	-0,02
b_{21}	0,70 ***	0,81 ***	0,85 ***	0,91 ***	0,97 ***	0,91 ***
b_{02}				2,28 ***	3,25 *	-0,47
b_{12}				1,44 ***	0,58 **	0,57 ***
b_{22}				0,03	0,26	0,32 **
p(1,1)				0,98 ***	0,96 ***	0,90 ***
p(2,2)				0,85 ***	0,79 ***	0,41 ***

***, ** & * Significance at 5%, 10% & 15% levels respectively

Parameter estimates from single regime GARCH(1,1) model are mostly statistically significant for all three countries stock market indices. Comparatively, with higher constant mean coefficient (a_{01}) Saudi Arabia stock market has been producing higher returns than that in Singapore. Additionally, the higher returns are associated with higher variance (b_{01} for Saudi Arabia greater than that of Singapore). This is in line with the typical investment return and risk relationship. One of the common features obtained from variance modeling of oil-exporting and oil-importing economies is that the aggregate persistency of the past shocks is more detrimental than the immediate past shock. This is evident from b_{21} coefficient being greater than b_{11} coefficient for all the stock market return variance structure. Considering such statistically significant results from single-regime volatility model, similar phenomenon is now applied in regime-switching structure to capture any long term inconsistency in the relationship.

In column five, six and seven of table 5, parameter estimates of regime-switching GARCH(1,1) structure are presented. Before the interpretation of the parameter estimates, it is important to retrieve that regime-switching in volatility models has been allowed on variance behavior but not in mean return. Model through markov two states process has separated two regimes according to the variability in stock return variances. Thus the differentiation of the regimes has got a new form of high variance regime and low variance regime. Alongside, the parameter estimates in variance structures are different to that in a normal GARCH model. Before reasoning the cause for such differences let's note the structure of variance equations in regime-switching GARCH model given in equations (1.17) and (1.18). Here within each regime the variance term at time t is dependent on immediate lag squared errors (u^2_{t-1}) and the immediate lag variance term (h_{t-1}). Further break down of each lag conditional variance term is associated with both means and variances of two regime frameworks as shown in equation (1.22). Thus the shock persistency variable (h_{t-1}) is not exactly the same as in single-regime normal GARCH model. But it is well accepted that the past shock(s) persistence effects is effectively captured within it. This innovation on modeling the variance was made by Gray (1996) as a succession over the arguments of Cai (1994) and Hamilton and Susmel (1994) of path dependence inherent in regime-switching GARCH model. According to Gray (1996) this structure in equation (1.22) breaks the path dependency of GARCH framework but the shocks persistency effect exists. Hence the parameter estimates of lag squared error term and lag conditional variance term hold the similar interpretation as in normal GARCH model. It is of importance that the impact could be judged through the estimates.

Parameter estimates of regime-switching GARCH (1,1) model for an oil-exporting economy, Saudi Arabia, have clearly identified two regimes in volatility of stock market return. As the constant term $b_{01} < b_{02}$, regime-1 is the low volatility regime and regime-2 is high volatility regime. For further clarity in identification of regimes, the following figure 9 presents the regime-1 ex-ante and smoothed (blue line) probabilities along with the stock market return graph at the corresponding time period. The squared errors from respective regime mean equation represents the actual volatility. The fitted variance (blue line) according to the estimated parameter for equations (1.17) and (1.18) are presented together with the actual variance (black line).

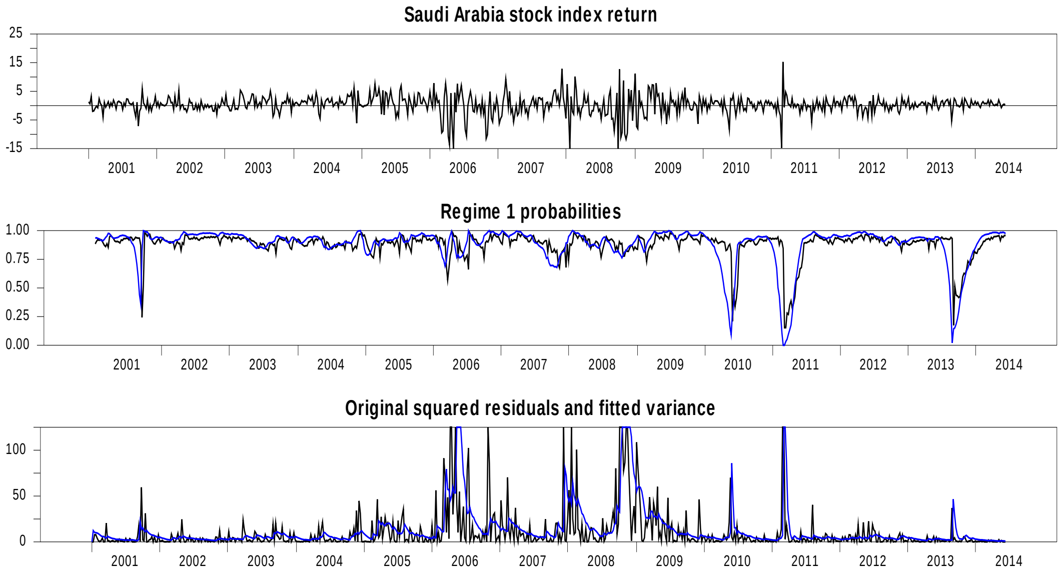

Figure 9. High volatility regime probabilities and the stock return variance.

From the graphs above, the low actual or fitted variance corresponds to high probabilities of regime-1. Clearly, a period from 2002 to 2004 is a low volatility period with high probabilities value of regime-1. In contrast, whenever happens a drop in regime-1 probabilities (meaning regime-2 occurs) the corresponding variance is higher. For instance, the period between 2010 and 2011 is a high volatility period where the probability of regime-1 has dropped. One of the important distinctions between single-regime and regime-switching GARCH model is obtained through the regime varying sensitivity to recent shock and aggregate persistency of shocks. The low volatility regime

(regime-1) is characterized by low sensitivity to recent shocks ($b_{11}>b_{12}$) and highly persistent effects of past shocks ($b_{21}>b_{22}$). The coefficient estimates in regime-2 suggests the high impact of recent shock but fairly low persistency of shocks during high volatility periods. This particular distinction as different behavior of volatility at different time periods is shadowed in single-regime structure.

Regarding the regime-switching GARCH estimates of an oil-importing economy, Singapore, regime-1 corresponds to high volatility regime and regime-2 the low volatility regime ($b_{01}>b_{02}$). Comparatively during the high volatility regime the sensitivity to recent shock is fairly low and shocks persistency is high. This results look opposing compared to that obtained for Saudi Arabia stock market volatility. Mean time the switching probability coefficients p(1,1) and p(2,2) suggest that the low volatility regime (regime-2) rarely exists as the probability of switching from regime-2 to regime-2 is just 41%. Hence, it is evident that the mostly dominant regime in Singapore stock market is the high volatility regime (regime-1)[11]. On such a background, the results for the mostly dominant regime in both the countries are of similar features, meaning that the past shocks persistency is higher and the recent shock has minimum impact on stock market volatility.

2. *Such features inherent in regime-switching GARCH model partially favor the purposed research question 2. In the context of univariate stock market volatility modelling, regime-switching volatility model outperform regime-switching mean and single-regime volatility models.*

One of important aim of market selection procedure was to judge the impact of oil price shocks on those target economies. Selected economies are assumed to be most likely affected by movement in oil price. Thus the volatility relationship obtained above for these countries stock market are further analyzed incorporating the role on oil price changes on stock market volatility on the following heading.

5.2.2. Results of single-regime and regime-switching Extended GARCH (1,1) model

Specification of the Extended GARCH models is presented in the empirical framework section above. The impact of oil price changes on stock market returns and stock market return volatility is assessed using a bivariate GARCH (1,1) structure. Specifically, oil price

[11] This feature in regimes categorization has been further analyzed by the incorporation of an external factor impact on the variance equation in the following model.

changes factor is incorporated in both the mean and the variance equations. Results of single-regime and regime-switching Extended GARCH model are presented in table 6 below.

Table 6. Estimates of Extended GARCH(1,1) models.

Sample of weekly stock market index return (r_t) and oil price change ($r_{(oil)t}$) are under specification for a sample period of 03/01/2001 to 11/06/2014.

In single-regime Extended GARCH(1,1) model;
$r_t = a_{01} + a_{02} r_{(oil)t-1} + u_t$, where $u_t \sim N(0, h_t)$, $u_t = v_t \sqrt{h_t}$ and $v_t \sim N(0,1)$. Also, $h_t = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1} + b_{31} r_{(oil)t-1}$

In regime-switching Extended GARCH(1,1) model;

$$r_t \, I\Phi_{t-1} \sim \begin{pmatrix} N(a01 + a11 r(oil)t-1,\ h1t) \text{ w.p. } p1t \\ N(a02 + a12 r(oil)t-1,\ h2t) \text{ w.p. } 1-p1t \end{pmatrix},$$

$h_{1t} = b_{01} + b_{11} u^2_{t-1} + b_{21} h_{t-1} + b_{31} r_{(oil)t-1}$ and $h_{2t} = b_{02} + b_{12} u^2_{t-1} + b_{22} h_{t-1} + b_{32} r_{(oil)t-1}$,
where p_t and $1-p_t$ are the probabilities of economic state being in regime-1 and regime-2, respectively.

	Extended GARCH(1,1) model					
	Estimate (Single-regime)			Estimate (Regime-switching)		
Coefficient	*Saudi Arabia*	*Norway*	*Singapore*	*Saudi Arabia*	*Norway*	*Singapore*
a_{01}	0,50***	0,46 ***	0,33 ***	0,48 ***	0,94 ***	0,67 ***
a_{02}				0,78 ***	-2,12	-0,03
a_{11}	-0,05 ***	-0,04	-0,04 *	-0,04 ***	-0,04	-0,10 ***
a_{12}				-0,16	0,03	0,04
b_{01}	0,33 ***	0,71 ***	0,18 *	0,20 ***	-0,10	1,18 ***
b_{11}	0,26 ***	0,15 ***	0,14 ***	0,02	0,09 ***	-0,02 *
b_{21}	0,73 ***	0,81 ***	0,85 ***	0,90 ***	0,65 ***	0,50 ***
b_{31}	0,09 **	0,00	0,02	0,04	0,12 **	0,25 ***
b_{02}				0,91 *	-1,67	-0,89
b_{12}				1,47 ***	-0,05***	0,07 ***
b_{22}				0,12 *	2,11 ***	1,27 ***
b_{32}				-0,09	-0,03	-0,09 *
p(1,1)				0,99 ***	0,80 ***	0,75 ***
p(2,2)				0,87 ***	0,09 ***	0,80 **

***, ** & * Significance at 5%, 10% & 15% levels respectively.

Results of single-regime Extended GARCH (1,1) model for both the oil-exporting and the oil-importing economies are similar. Specifically, lag oil price changes have significant negative influence on mean returns and positive impact on volatility of stock market returns in both Saudi Arabia and Singapore. But the magnitude of the coefficients for oil price changes variable in mean and variance equations are all very small in case of both the countries. This would mean no notable impact of oil price changes on stock market return and volatility on either of oil-exporting or oil-importing economies. For the further confirmation of these results the regime-switching Extended GARCH (1,1) model was introduced and the following are the results obtained.

Saudi Arabia as a representation of oil-exporting economy, possess two regime structures in stock market volatility. The low volatility episode (regime-1) and high volatility episode (regime-2) are characterized with the similar relationship regarding the impact of recent shocks and persistency of the past shocks as in regime-switching GARCH (1,1) model before. During the high volatility regime impact of individual shock has strong immediate impact on volatility but dies out very quickly ($b_{12} > b_{11}$ and $b_{22} < b_{21}$) as persistency of the shocks is comparatively low. But in low volatility regime the shocks have long lasting effects ($b_{21} > b_{22}$). The impact of oil price change in stock market return of Saudi Arabia is negative in both the volatility regimes. Such impact is significant but fairly negligible (a_{11} = -0.04) during the low volatility period and not significant during the high volatility period. Hence, oil price changes showed no notable impact on mean return of Saudi Arabia stock market index during both the volatility regimes. Concerning the impact of oil price change on stock market volatility, both the regimes coefficients, b_{31} and b_{32}, are small and not statistically significant. To validate such results, coefficients of regime-switching Extended GARCH (1,1) model for another oil-exporting target economy ,Norway could be referred. For Norway, firstly, the regime persistency is itself negligible during regime-2 [p(2,2) = 9%]. Secondly, 3/4th of the oil price changes impact coefficients are not statistically significant. From these results it is evident that as a whole the oil price changes has no notable impact on stock market return dynamics of oil-export dependent economies. The possible reasons for such a result are discussed later in the conclusion section.

In line to the results of regime-switching GARCH model, parameter estimates of regime-switching Extended GARCH (1,1) model for the target oil-importing economy, Singapore, are displayed in seventh column of table 6. Notablely, GARCH shocks persistency effect is higher during the low volatility regime ($b_{22} > b_{21}$). Thus in general the inherent impact of oil price changes on stock market volatility turned the persistency of shocks to be more influential during the low volatility regime. Low volatility regime persistency is as well high [p(2,2)= 80%] with the incorporation of oil price changes effect on stock market index innovations. The additional variable, oil price changes, implied on mean return and variance equations of Singapore stock market has shown a significant impact which is different to that obtained for oil-exporting countries. As expected, during the high volatility regime, oil price changes have negative impact on mean return. Such a relationship is highly significant, statistically and economically. During the low volatility regime the impact on mean return is positive but the coefficient is very small (a_{11} = 0.04) and not significant. This could be generalized as such that oil price changes have notable influence in stock market return of Singapore during high volatility periods but not during the low volatility periods. But the important relationship that this thesis research seeks to obtain is between the stock return volatility and the oil price changes. In Singapore stock market, oil price changes has significant positive relationship to return volatility during the high volatility regime (b_{31}=0.25) and has significant negative relationship during the low volatility period (b_{32}=-0.09). These statistics have most likely valid economic significance which is discussed in the conclusion section of the thesis.

3. *Results for the implied volatility model has partially supported research question 3. In target oil-exporting countries, role of oil price changes to influence stock market return is fairly negligible during both the high and low volatility economic-episodes. In target oil-importing country, oil price changes depress the stock market return during high volatile economic-regimes. Though not a significant big impact during low volatility regime, oil price changes impact on stock market return of oil-importing country varies in two different economic-regimes*.

4. *Similarly, in response to research question 4, no significant influence of oil price changes are observed on stock market volatility of target oil-exporting countries during both the economic-regimes. However, evidence of strong intensifying impact of oil price changes on stock market risk of target oil-exporting country have been detected during the high volatile economic-regime. In low volatile economic-regime, the impact is just opposite.*

Overall, for both the oil-exporting and the oil-importing economies under consideration, the GARCH effects are common during high and low volatility regimes. Past shocks persistency is higher during the low volatility regime than in high volatility regime. In other words, shocks on stock market indices die out quickly during high volatility periods but has long lasting effect during the low volatility regime for both the oil exporting and importing economies. Regarding the impact of oil price shocks on stock market return and volatility, no significant evidence is found for target oil-exporting economies in both the regimes. In contrast, oil price shocks exhibit negative impact on volatility of stock market in oil-importing countries specifically during the low volatility regime. But during the high volatility regime, oil price shocks negatively affect the stock market return and positively affect the volatility in oil-importing economy.

6. CONCLUSION

Long term economic relationship has been found affected by the change in economic phenomenon within the estimation period. The interconnection and dependency of macro-economic variables could be varying at different states of economic growth. Thus modeling economic relationship as a single regime structure would be misleading. Markov regime-switching model that accounts for structural breaks and switching flexibility is detected to adequately capture the inherent characteristics of the data in long run. In particular, the assumption of stochastic properties of residuals is found closely incorporated by a regime-switching model than does the single-regime model mostly implied in defining the economic relationships. Empirically two regimes have been detected in stock market performance behavior of the target oil-exporting and oil-importing countries. Regime in stock market representing high mean return and low volatility coincides with the episodes of stable economic growth. The other regime with low mean return and high volatility in stock market coincides with the periods of economic downfall and recessions.

Implied regime-switching volatility models conclude that past shocks in stock markets behave differently during two distinct volatility regimes. Mostly stock markets are found more volatile during the recession periods. During such unstable economic growth periods monetary authorities actively revise the policies, for instance by changing the interest rates. Such policies are likely to cause fluctuations in the financial markets. Uncertainty and loss in stock trader's confidence would make the markets less efficient than usual. Possibility of high speculation in financial markets could be another cause of shocks in stock market performance during unstable growth period. Collectively, these activities deliberate a message that stock market shocks may not be always caused by the relevant information during economic downturns. Intuitively such shocks may immediately make the stock market more volatile but are less likely to have long-term persistency (for instance see Daal et al., 2007; Friedman and Laibson, 1989; Henry, 2009; among others). Consequently high volatility regime in stock markets has been characterized by low persistency of past shocks. In contrast, during the period of economic stability, stock markets are less volatile and more efficient. Accordingly, shocks in stock market performance persist longer during low volatility regime. A regime-switching model has been capable of defining such dynamic relationship effectively that is ignored by a commonly implied single-regime model.

Stock market return and volatility in the target oil-exporting economies are found less influenced by the movements in oil price. Both in Saudi Arabia and Norway, oil price changes has not shown significant notable impact on stock market volatility during both the volatility regimes. Market efficiency and shareholder structure in Tadawul stock exchange are some of the highlights considered in the earlier studies (for instance Jouini, 2013). A significant portion of total stock market capitalization in Tadawul Stock Exchange has been owned by a group of few investors in oil business. Such structure is perceived to reduce the trading volume (low turnover) of stocks which adversely affect the market efficiency. Similarly, the major ownership of income from oil-exporting country, Norway, is solely the government and thus remains salient for any changes in oil price. These specific characteristics in Saudi Arabia and Norway stock markets demonstrate a valid economic framework to justify the nature of our empirical results.

Contrastingly, movement in oil price is keen to influence stock market performance in oil-importing country. As expected in Singapore, the rise in oil price drops the stock market return and makes the market more volatile especially during the regime of economic instability. While in low volatility regime (stable growth periods) the impact of oil price changes is more apparent on the stock market volatility rather than on mean return. Comparatively, information regarding the changes oil price is found relevantly integrated in the stock prices as it has been reducing the stock market volatility during the period of stable economic growth. Hence, oil price relationship to stock market volatility in oil-importing countries alters during stable and unstable economic-regimes.

6.1. Practical Implications

Investors in oil-importing countries could benefit the risk assessment[12] in relation to oil price fluctuations. Historically, reduced demand in the market during the period of low economic growths and recessions may decelerate the global price. Surprisingly, stock market investors in oil-importing economies are likely to benefit for any downward movement in oil price. We have found empirical evidence that changes in oil price has indirect relationship to mean stock market return and direct relationship to volatility in net oil-importing country during unstable growth periods. Notably risk of oil price fluctuation in Saudi Arabia and Norway stock markets seems negligible. This confronts that the

[12] Christoffersen and Diebold (2000) argue forecastable volatility in short run is relevant for risk management.

investment diversification in stock markets of net oil-importing and net oil-exporting economies would perform a suitable hedging for oil price risk. Results could equally contribute to policy makers in oil-importing countries particularly during episodes of high volatile financial markets to assess and control oil price risk. Other macro-economic determinants like interest rate and money supply could be addressed to reduce such unusual movement in stock markets.

Extension of the research including a bunch of net oil-importing and net-oil exporting countries would contribute to generalize the results. Alongside, augmented E-GARCH structure (for instance Henry, 2009) allowing oil price changes as exogenous factor in mean and variance equations of regime-switching volatility model could be implied as an advancement to the implied model.

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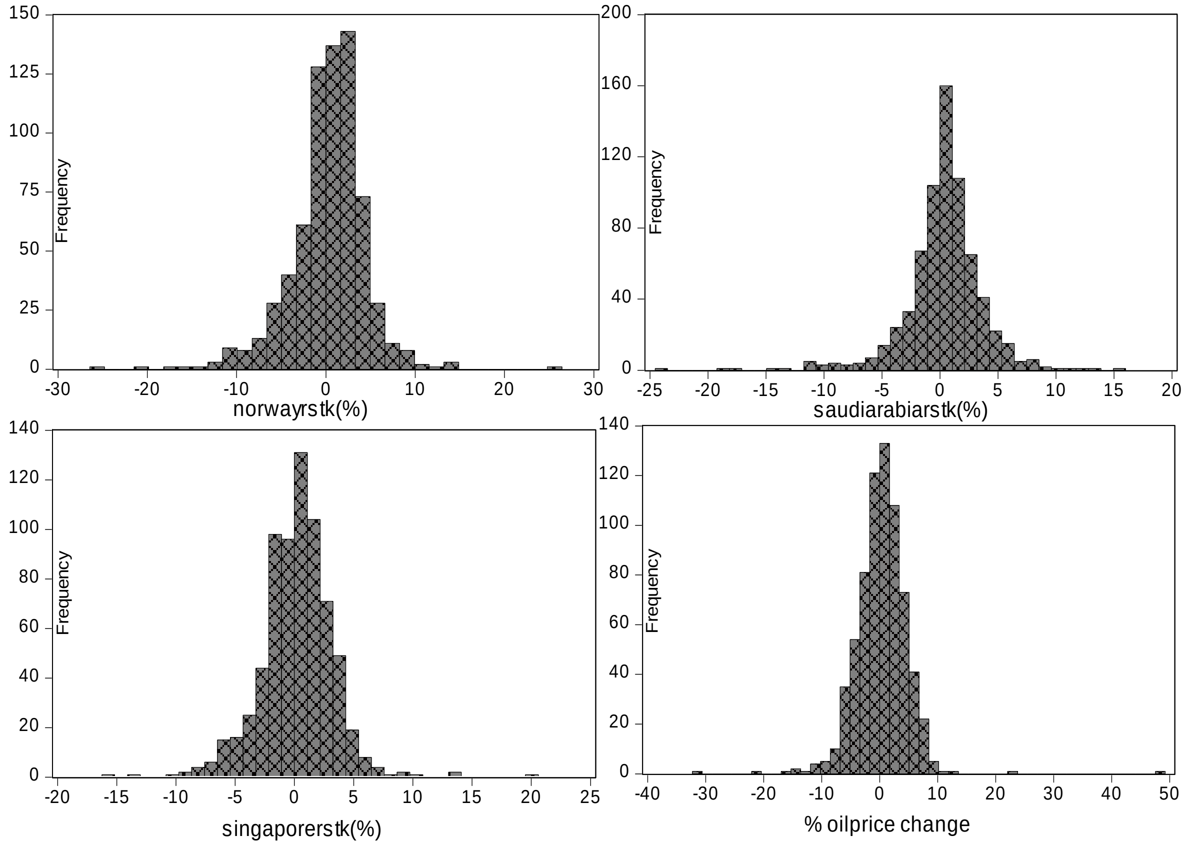
APPENDICES

Appendix 1

Histograms for the series of stock market returns of Norway, Saudi Arabia & Singapore and oil price changes.



Distribution of the variables.

Appendix 2

Augmented Dickey-Fuller test results.

		Test critical values at:		
Stock market returns	ADF test statistic	1% level	5% level	10% level
Norway	-14,539	-3,439	-2,865	-2,569
Saudi Arabia	-24,483	-3,439	-2,865	-2,569
Singapore	-25,328	-3,439	-2,865	-2,569
Oil price changes	-24,248	-3,439	-2,865	-2,569

In table above, ADF test statistics (shaded column) for all the series are more negative than their respective critical values. Hence, the null hypothesis of unit root in the returns series or unit root in oil price changes series is convincingly rejected.

Kwiatkowski-Phillips-Schmidt-Shinteststatistic test results.

		Asymptotic critical values:		
Stock market returns	KPSS test statistic	1% level	5% level	10% level
Norway	0,059	0,739	0,463	0,347
Saudi Arabia	0,219	0,739	0,463	0,347
Singapore	0,076	0,739	0,463	0,347
Oil price changes	0,055	0,739	0,463	0,347

In table above, the KPSS test statistics (shaded column) for all the series do not exceed the respective critical values at 1%, 5% and 10% level. Hence, the null hypothesis of stationary in returns series or stationary in oil price changes series cannot be rejected.