Chapter – 2

REVIEW OF LITERATURE

2.1 Introduction

In the introductory chapter, historical basis of oil-gas price linkage and the recent scenario of global and Indian crude oil and natural gas market have been discussed in detail followed by discussion on background, scope, and objectives of the present study. The present chapter, deal with review of literature, which is an important aspect of this research. It helps to trace out the past trends in research pertaining to crude oil and natural gas pricing relationship besides identifying the way in which research in the thrust area has been carried out with a focus on identifying an optimal model for oil-gas price relationship and price forecasting.

Incidentally, on account of the importance of crude oil and natural gas to the economy, there has been an avalanche of studies since the oil shock of 1973-74 on forecasting crude oil price. There is also lot of studies conducted to understand the long-term and short-term relationship, identifying the inter-linkages between various commodities traded in leading bourses at National and International level. It is found that the issue of checking the efficiency and inter-linkages of various financial and commodity markets of a country and that of other countries are topics of interest for traders, stakeholders, academician and analysts.

Though spot market price of various commodities, especially energy commodities react to the factors independent to their demand and supply, due to increased linkage and
close association of these products and markets there exists some relationship between them. But, questions such as which market reacts first, whether there exist any relationship between them, and whether there is any possibility of forecasting their volatility etc., remains unanswered. Testing of the existence of long-term and short term relationship is not new in developed markets. A great deal of research has been conducted earlier to examine such relationships. There are many empirical studies that provide indirect evidence on the relationship between volume and price as well as spot and futures prices of crude oil and natural gas markets. In this chapter various previous studies relating to long term and short term relationship, inter-linkage between national and international markets, and forecasting of energy commodities prices have been reviewed. This review has enabled the researcher to identify some new concepts, methodological approaches, and current knowledge relevant to the present study. The way in which the present study differs from the earlier ones is also discussed in detail. Some of such relevant studies are documented for identifying the research gap, based on which this thesis is built on.

For clear and easy understanding, encouraging logical flow of ideas, current and relevant literature which consist a comprehensive view of the previous research on the topic is presented in the following five sub-headings.

(a). Empirical studies on long and short term relationship across two or more different markets
(b). Empirical studies on long and short term relationship between commodities in a domestic market.
(c). Empirical studies on volatility and price forecasting across markets.

(d). Empirical studies on long and short term relationship between energy commodities and other commodities / parameters

(e). Empirical studies involving energy commodities with focus on Indian markets

A very brief review of the related and recent studies under each category is documented below;

2.2 Empirical Studies on Long Term and Short Term Relationship across Different Markets:

1. Jones and Kaul (1996)\textsuperscript{98} tested whether the reaction of international stock markets to oil shocks can be justified by current and future changes in real cash flows and/or changes in expected returns. They found that aggregate stock market returns in the U.S., Canada, Japan and the U.K. were negatively sensitive to the adverse impact of oil price shocks on those economies. From the data collected from 1970 to 1995 they used the GARCH and Granger causality test and argued that investors in stock markets under react to oil price changes in the short run. They concluded that in the postwar period, the reaction of U.S and Canadian stock prices to oil shocks can be completely accounted for by the impact of these shocks on real cash flows alone. In contrast, in both the United Kingdom and Japan, innovations in oil prices appear to cause larger changes in stock prices than can be justified by subsequent changes in real cash flows or by changing expected returns.

2. Silverstovs, Hegaret, Neumann and Hirschhausen (2005)\textsuperscript{99} investigated the degree of integration of natural gas markets and their relation to the oil price were explored through principal components analysis and Johansen likelihood-based co-integration procedure for Europe, North America and Japan markets for the period between the early 1990s and 2004. They found in both the analysis a high level of natural gas market integration within Europe, between the European and Japanese markets as well as within the North American market. At the same time, the obtained results suggested that the European and the North American as well as the Japanese and North American markets were not integrated, confirming with the earlier studies that the gas markets were not integrated across continents.

3. Haesun, Mjelde and Bessler (2008)\textsuperscript{100} studied the relationships among eight North American natural gas spot market prices. The study provided a dynamic picture of daily information flow among natural gas spot markets from 1998 to 2007. The study used the error correction model (VECM) as the basic tool for analysis. Results indicated that the Canadian and U.S. natural gas market was a single highly integrated market. Further results indicated that price discovery tends to reflect both regions of excess demand and supply. Across North America, Malin Hub in Oregon, Chicago Hub, Illinois, West Texas Intermediate, Henry Hub and Louisiana region were the most important markets for price discovery. Opal Hub in


Wyoming was an information sink in contemporaneous time, receiving price information but passing on no price information. Alberta Energy Company (AECO) Hub in Canada received price signals from several markets and passes on information to Opal and the Oklahoma region.

4. **Maslyuk and Smyth (2009)**\(^{101}\) studied co-integration between oil spot and future prices of the same and different grade in the presence of structural change. The purpose of the study was to examine whether crude oil spot and futures prices of the same and different grades were co-integrated using a residual-based co-integration test that allows for one structural break in the co-integrating vector and high-frequency data. For the analysis, U.S. WTI (West Texas Intermediate) and UK Brent was chosen as the representative crudes since these two crudes have well-established spot and futures markets. The results revealed that spot and future prices of the same grade as well as spot and future prices of different grades were co-integrated.

5. **Matthew, Jian and Kuan (2009)**\(^{102}\) examined whether Dubai crude oil and Brent crude oil futures prices were stationary as well as whether there exist a long-run equilibrium relationship in the oil markets. Further, they investigated the dynamic process of the endogenous variables and future periods through VECM. The study period was from January 3, 2000 through October 1, 2009 with a total of 2481 daily samples. They found that Brent crude oil prices lead Dubai crude oil prices, and in the long-term, however, both Dubai and Brent crude oil prices will reach


equilibrium. Their co-integration and VECM results were consistent with the one-great-pool concept advocated by Adelman (1984).

6. Shaharudin, Samad, Fazilah, Bhat and Sonal (2009)\textsuperscript{103} examined the effect of oil prices movements on the stock price of oil and gas companies in three different markets (U.S., India and UK) using daily data. The dynamic interaction between oil prices and stock prices was investigated in the presence of economic variables like interest rates and industrial productions. They collected the daily data for the period August 08, 2003 to August 8\textsuperscript{th}, 2008. The oil price was the London Brent crude oil Index. The oil stocks included the Exxon Mobil and Chevron stocks from the NYMEX. Reliance Industries and Indian Oil Corporation Limited stocks were collected from the NSE of India and Royal Dutch Shell and Gazprom stocks from the LSE. They employed unit root tests, co-integration tests, variance auto regression, error-correction models with variance decomposition and impulse response and ARCH/GARCH models. The results suggested that there exists significant short run and long run relationship between oil price and the oil stocks including the effect of the other variables such as interest rate and the stock index. The oil price volatility transmission has a persistent effect on the volatility of the stocks of the oil companies in all the countries that were taken up for the study.


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7. **Svetlana and Smyth (2009)** examined whether crude oil spot and future prices of the same and different grades were co-integrated using a residual-based co-integration test that allowed for one structural break in the co-integrating vector and high-frequency data. They used daily spot and futures prices at 1 and 3 months to maturity for the two benchmark crudes over the period spanning January, 1991 to November, 2008. They chose the U.S. WTI traded at NYMEX and the UK Brent traded at ICE as the representative crude oil for this analysis. The source for the spot prices was the Energy Information Administration (EIA), while future prices were taken from NYMEX and ICE. They found that spot and future prices of the same grade as well as spot and future prices of different grade were co-integrated.

8. **Demirer and Kutan (2010)** examined the informational efficiency of crude oil spot and futures markets with respect to OPEC conference and U.S. Strategic Petroleum Reserve (SPR) announcements. Daily spot and futures prices for light sweet crude oil from March, 1983 to June, 2005 were taken up for the analysis. They concentrated on crude oil contracts traded in the U.S. and employed the event study methodology to examine the abnormal returns in crude oil spot and futures markets around OPEC conference and SPR announcement dates between 1983 and 2008. Their findings regarding OPEC announcements indicated an asymmetry in that only OPEC production cut announcements yield a statistically significant

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impact with the impact diminishing for longer maturities. They also found that the persistence of returns following OPEC production cut announcements created substantial excess returns to investors who take long positions on the day following the end of OPEC conferences.

9. **Ravichandran and Alkhathlan (2010)** studied the impact of oil prices on GCC (Gulf Cooperation Council) stock market and found that their stock markets were likely to be susceptible to change in oil prices because they were the major suppliers of oil. Data employed in this study were daily stock market price indices and NYMEX oil price during the period March 2008 to April 2010. They used the Johansen’s Co-integration, VAR and VECM. The results confirmed that there was an influence of oil price change on GCC stock market returns in the long-term.

10. **Almadi and Zhang (2011)** examined whether world’s crude oil benchmarks (West Texas Intermediate in North America, Brent crude in Europe, and Dubai and Oman crude oil prices in Asia were stationary as well as whether there exist a long-run equilibrium relationship between these markets. The study period was from January 1st, 1990 through November 19th, 2010 with 5450 daily samples. They found that the prices of the four main crude oil benchmarks were co-integrated indicating that in the long run the world oil market was unified rather than regionalized. They also found that Western oil markets (WTI and Brent) lead East-of-Suez (EOS)

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markets (Dubai and Oman). Specifically, this study found that WTI significantly leads Brent, Dubai and Oman crude oil prices; Brent significantly leads Dubai and Oman crude oil prices; and Oman moderately leads Dubai crude oil prices. They concluded that in the long-term the prices of the four (WTI, Brent, Dubai and Oman) crude oil main market will reach equilibrium.

11. Pushpa, Chakraborty and Mathur (2011)\textsuperscript{108} investigated the existence of long-term relationships between oil prices and stock market prices of two big emerging economies in Asia viz., India and China. Since India and China were the major oil consuming market, their stock markets were likely to be susceptible to oil price fluctuations. A data series from January, 2000 to May, 2011 was considered. The stationarity of the data series were checked using ADF Test. Johansen’s co-integration model was applied to find out the co-integration among the oil prices and stock prices of India and China. VECM was employed to trace the existence of long run relationship between the variables\textsuperscript{109}. The results of the co-integration analysis found the existence long-run relationship between oil prices and stock market prices for both the countries. The trace and maximum Eigen value test results also revealed the existence of unique co-integrating vectors between test variables. They provided evidence on the existence of at least one co-integrating vector in the model and therefore concluded that the variables exhibit a long-run association between them.


\textsuperscript{109} Retrieved from http://www.eurojournals.com/mefe_5_02.pdf?lang=en_us&output=json
2.3 Empirical Studies on Long Term and Short Term Relationship between Commodities in Domestic Markets.

12. Serletis (1994)\textsuperscript{110} examined the number of common stochastic trends in a system of three petroleum futures prices (crude oil, heating oil and unleaded gasoline) using daily data from 3\textsuperscript{rd} December, 1984 to 30\textsuperscript{th} April, 1993 in Canada. Johansen’s maximum likelihood approach, for estimating long-run relations in multivariate vector autoregressive models was used. The research concluded that all three prices were driven by only one common trend, suggesting that it was appropriate to model energy futures prices as a co-integrated system.

13. Huang, Masulis and Stoll (1996)\textsuperscript{111} investigated the dynamic interactions between oil futures prices traded on the NYMEX and U.S. stock prices by examining the effects of energy shocks on financial markets. In particular, they examined the extent to which these markets were correlated, with particular attention paid to the association of oil price indexes with the S&P 500 index, 12 major industry stock price indices and 3 individual oil company stock price series. The vector autoregressive VAR approach was used to examine the lead-lag relation between oil futures returns and stock returns while controlling for interest rate effects, seasonality, and other effects. The conclusions from the VAR approach were the same as from the simpler bivariate cross correlations estimated earlier in the study. Oil futures returns were not correlated with stock market returns, even


contemporaneously, except in the case of oil company returns. Despite the frequently cited importance of oil for the economy, there was little evidence of such a link in the prices of stocks other than oil companies.

14. **Gunnarshaug and Ellerman (1997)**\(^{112}\) examined natural gas pricing at five city gate locations in the Northeastern U.S, using daily and weekly price series for the period 1994-97. In particular, the effects of the natural gas price at Henry Hub, weather and the natural gas inventory levels in the region were examined by regression. The results indicated that natural gas spot city gate prices in the Northeastern U.S. were influenced mainly by the Henry Hub spot price and local heating degree-days. Storage inventory level supplying to the Northeast appears to have little influence.

15. **Ache, Gjolberg and Volker (2000)**\(^{113}\) examined the relationship between crude oil and refined product prices in a multivariate framework. This allowed them to test several assumptions of earlier studies. They used the OLS and co-integration approach during the period from January, 1992 to November, 2000. They focused on the North West European crude oil market and found that the crude oil price was weakly exogenous and that the spread was constant in some but not all relationship. Moreover, the multivariate analysis showed that the link between crude oil prices and several refined product prices implies market co-integration for these refined products.


16. **Moosa and Silvapulle (2000)**[^1] examined the price and volume relationship in the crude oil futures market using linear and nonlinear causality testing for the presence of a causal relationship between price and volume in the crude oil futures market. The data sample used in this study consists of daily observations on futures prices and volumes of the WTI crude oil covering the period between 2\textsuperscript{nd} January, 1985 and 11\textsuperscript{th} July, 1996. The results of linear causality testing revealed that presence of causality running from volume to price but not vice versa. While the result of testing for nonlinear causality was inconsistent, most of the evidence showed that causality runs in both directions.

17. **Bahram, Chatrath, Raffiee and Ripple (2001)**[^2] analyzed the price dynamics of Alaska North Slope crude oil and L.A. diesel fuel prices by employing VAR methodology and bivariate GARCH model to show that there was a strong evidence of a unidirectional causal relationship between the two prices. The L.A. diesel market was found to bear the majority of the burden of convergence when there was a price spread. This finding may be seen as being consistent with the general consensus that price discovery emanated from the larger, more liquid market where trading volume was concentrated. The contestability of the West Coast crude oil market tends to cause it to react relatively competitively, while the lack of contestability for the West Coast diesel market tends to limit its competitiveness, causing


price adjustment to be slow but to follow the price signals of crude oil. Their findings also suggested that the derived demand theory of input pricing may not hold in this case and Alaska North Slope crude oil price was the driving force in changes of L.A. diesel price.

18. Chinn, Leblanc and Coibion (2005)\textsuperscript{116} examined the relationship between spot and futures prices for energy commodities (crude oil, gasoline, heating oil markets and natural gas) obtaining the data for four variants viz., WTI crude oil, Henry Hub natural gas, Gulf Coast gasoline, and No.2 Gulf Coast heating oil. All the futures prices were collected from NYMEX from 1st January, 1999 to 31\textsuperscript{st} October, 2004 as reported by Bloomberg. Using ARIMA and used OLS, they concluded that futures prices were an unbiased and accurate predictor of subsequent spot prices.

19. Menzie, Blan and Coibion (2005)\textsuperscript{117} examined the relationship between spot and futures prices for four energy commodities in USA viz., crude oil (WTI), gasoline (Gulf Coast), heating oil (No.2 Gulf Coast) and natural gas (Henry Hub). In particular, they examined whether futures prices were an unbiased and/or accurate predictor of subsequent spot prices. Using NYMEX futures price data as reported by Bloomberg and were tested using OLS. They found that while futures prices were unbiased predictors of future spot prices for crude oil, gasoline and heating oil but not for natural gas prices at


the 3-month horizon. Futures prices appeared to predict subsequent movements in energy commodity prices only to a small extent.

20. Jose and Joutz (2006) examined the time series econometric relationship between the Henry Hub natural gas price and the WTI crude oil price. Typically, this relationship has been approached using simple correlations and deterministic trends. When data have unit roots as in this case, such analysis was faulty and subject to spurious results. The analysis supported the presence of a co-integrating relationship between the crude oil and natural gas price time series, providing significant statistical evidence that WTI crude oil and Henry Hub natural gas prices have a long-run co-integrating relationship. A key finding of the analysis was that natural gas and crude oil prices historically have had a stable relationship, despite periods where they may have appeared to decouple. A VECM of crude oil and natural gas prices was estimated, and facilitated the analysis of the long-run co-integration relation and short-run adjustments in prices. The estimation of the model resulted in identifying evidence of a stable relationship between natural gas and crude oil prices.

21. Rukmani and Bartleet (2006) aimed to examine what impact the changes in the world price of oil had on New Zealand’s economic growth over the period 1989-2006. Several hypotheses concerning the impacts of oil price shocks on economic growth were empirically examined for petroleum

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market deregulation, i.e. post-1989 period. The issue of oil price shock impacts on economic growth was considered using the VAR methodology based on quarterly data. The short run impact of oil price shocks on economic growth has been considered in a multivariate framework. This allowed analyzing the direct economic impact of oil price shocks, as well as the indirect linkages. The models estimated employed the linear oil price and two leading nonlinear oil price transformations to examine various short run impacts. Utilizing the Wald and Likelihood Ratio tests of Granger Causality, the later results indicated that linear price change, the asymmetric price increase and the net oil price variables were significant for the system as a whole, whereas the asymmetric price decrease was not. Following the causality analysis of oil price-growth nexus, the generalized impulse responses and error variance decompositions reaffirm the direct link between the net oil price shock and growth, as well as the indirect linkages.

22. Switzer and Mario (2006)\textsuperscript{120} studied extreme volatility, speculative efficiency and the hedging effectiveness of the oil futures markets. They investigated the efficiency of the NYMEX light sweet crude oil futures contract during the period from January, 1986 to April, 2005 and also the sub-period of extreme conditional volatility that covered the onset of the Iraqi war (March, 2003) to the formation of the new Iraqi government (April, 2005) and also analyzed the effectiveness of alternative hedging models during such periods. Using the econometric tools of Fama’s (1984) regression

approach with monthly as well as the Johansen’s (1998) co-integration techniques, they found that crude oil futures contract prices were co-integrated with spot prices and unbiased predictors of future spot prices, including over the period prior to the onset of the Iraqi war and until the formation of the new Iraqi government in April 2005. Univariate GARCH models of the distribution of the spot and futures series revealed evidence of long-term volatility persistence and volatility clustering. The examination of GJR-GARCH model revealed significant volatility asymmetries in the futures and spot prices, which showed improvement in hedging performance when asymmetries were accounted.

23. Stelios and Cees (2008)\textsuperscript{121} investigated the linear and nonlinear causal linkages between daily spot and futures prices for maturities of one, two, three and four months of WTI crude oil. The data covered two periods October, 1991 to October, 1999 and November, 1999 to October, 2007. They examined the nonlinear causal relationships of VECM filtered residuals and investigated the hypothesis of nonlinear non-causality after controlling for conditional heteroskedasticity in the data using a GARCH-BEKK model. Whilst the linear causal relationships disappear after VECM co-integration filtering, nonlinear causal linkages in some cases persist even after GARCH filtering in both periods. These indicate that spot and futures returns may exhibit asymmetric GARCH effects and/or statistically significant higher order conditional moments.

24. Raymond Li (2010)\textsuperscript{122} evaluated in a multivariate framework the leading and lagging relationship among the spot prices for crude oil, gasoline, heating oil, jet fuel and diesel to assess whether or not the direction of price information flow that was to be predicted from derived demand theory was observed. Monthly spot prices of WTI light sweet crude oil, New York Harbor conventional gasoline, No.2 heating oil, kerosene-type jet fuel and Los Angeles No.2 diesel were used in the empirical analysis for a period from June, 1990 to May, 2010, with 240 observations. Econometric tools such as ADF & PP test, Residual Diagnostic Test, Johansen multivariate co-integration test and Granger causality test were used for the study which showed strong evidence that the price of crude oil and its refinery products were co-integrated. At the same time, the weak exogeneity test revealed that crude oil price transmitted exogenous shocks to the system in the long-run and changes in oil price were passed through to the refined product prices in the long run.

25. Westgaard, Estenstad, Seim and Frydenberg (2011)\textsuperscript{123} investigated the relationship between Gas oil and Brent Crude oil futures prices. The analysis was based on daily price series for five different contract lengths traded on ICE futures Europe. The price series and their first differences were tested for stationarity. Linear relationships between the pair-wise Gas oil and Crude oil contracts were then tested for co-integration. 1 and 2 month contracts covering data from 1994 to 2009 and Error Correction


Models were established to estimate the relationships. No co-integrated relationships were found for the 3, 6 and 12 month contracts covering the period 2002–2009, nor for the 1 and 2 month contracts for this period.

26. Lee, Huang and Yang (2012)\textsuperscript{124} employed the momentum threshold error-correction model with generalized autoregressive conditional heteroskedasticity to investigate asymmetric co-integration and causal relationships between WTI crude oil and gold prices in the U.S. futures market. They collected the data from May 1\textsuperscript{st}, 1994 to November 20\textsuperscript{th}, 2008. The empirical results showed that an asymmetric long-run adjustment exists between gold and oil. Furthermore, the causality relationship shows that WTI crude oil played a dominant role.

2.4 Empirical Studies on Volatility and Price Forecasting Across Markets.

27. Kumar and Manmohan (1992)\textsuperscript{125} investigated the efficiency of the NYMEX futures market and the forecasting accuracy of crude oil futures prices during the period June, 1985 to May, 1990. They analyzed the efficiency of the market in terms of the expected returns from trading in the futures contracts while accuracy of futures price forecasts has been analyzed by comparing it with the accuracy of forecasts obtained using random walk, time-series models, econometric models, and judgmental forecasts. Further, they examined the improvement in forecasting accuracy when futures prices were combined with forecasts from alternatives sources. The results suggested that there did not appear any systematic bias in crude oil


futures prices. Also, crude oil prices provided forecast that was, on an average, superior to those obtained from alternative techniques for short term horizons.

28. **Moosa and Al-Loughani (1994)**\(^{126}\) in their research paper presented empirical evidence on market efficiency and un-biasedness in the crude oil futures market. On the basis of monthly observations on spot and futures prices of the WTI crude oil, several tests were carried out on the relevant hypotheses. The data sample consists of monthly observations on three price series related to the WTI crude oil: spot price, three-month futures price and six-month futures price. The sample covers the period 1\(^{st}\) January, 1986 to 31\(^{st}\) July, 1990. The analysis of the results suggested that futures prices were neither unbiased nor efficient forecasters of spot prices. Furthermore, a GARCH-M model revealed the existence of a time varying risk premium.

29. **Herbert (1995)**\(^{127}\) studied relationship between the volatility of the natural gas futures price and maturity of the futures contract and estimated the volume of trading in the futures contract. Only data for the nearby month contracts was considered which gave approximately 20 observations per contract from January, 1990 to December, 1994 futures price from UK. By using regression analysis, it was found that the volume of trade rather than maturity explains the variance of the volatility. It was also discovered that past levels of volume of trade influence current variability of price volatility.

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but that past variability of price volatility has much less of an influence on current levels of trade.

30. Abosedra and Hamid (2004)\textsuperscript{128} evaluated the predictive accuracy of 1, 3, 6, 9 and 12-month crude oil futures prices for January, 1991-December, 2001 from NYMEX- WTI. In addition to testing for un-biasedness, a naive forecasting model was constructed to generate comparable forecasts, as benchmarks. The empirical findings revealed that futures prices and forecasts were unbiased at all forecast horizons. However, the 1st and 12-month futures prices were the only forecasts outperforming the naive, suggesting their potential usefulness in policy making. However, they also argued that continuing political instability of the Middle East and the inability of OPEC to offset market sentiment, among other factors, may in the future adversely affect the predictive accuracy of the 1 month and 12-month ahead futures prices.

31. Coimbra and Soares (2004)\textsuperscript{129} evaluated the OPEC crude oil price volatility forecasting performance of futures market prices from July, 1991 (9 months), from April, 1994 (12 months) and from January, 1998 (18 months). The stationarity of the series were tested using ADF test. Two alternative samples were considered (i) a full sample, from January, 1989 to December, 2003; (ii) a partial sample that excludes the Golf War effects, from January 1992 to December 2003. The results revealed the presence of a non-stationary variable integrated of order one, suggesting


the use of its first difference and suggested that it’s very difficult to forecast oil prices given its volatility. Finally, there was evidence of a positive correlation between futures market oil prices errors and the market expectation errors concerning the evolution of world economic activity. These results suggested an adjustment of the oil prices forecast based on futures markets whenever the market expectations on economic growth were different from the values underlying the macroeconomic projections.

32. **Moshiri and Foroutan (2006)**\(^{130}\) forecasted daily crude oil futures prices that were listed in NYMEX from 1983 to 2003. Traditional linear structural models have not been promising when used for oil price forecasting. Although linear and nonlinear time series models have performed much better in forecasting oil prices, there was still room for improvement. If the data generating process was nonlinear, applying linear models could result in large forecast errors. Finally they applied linear and nonlinear time series models. They used the software EViews-4 to estimate and forecast crude oil futures prices and discovered that linear ARMA (1, 3) and nonlinear GARCH (2, 1) models were the most suitable. However, the GARCH model outperformed the ARMA model.

33. **Yun (2006)**\(^{131}\) tried to answer the relative predictability of futures prices compared to the forecasts based on experts’ system and econometric models, using WTI crude oil spot and futures prices, for the period of October, 1998 to June, 2004. For regression models, this sample was divided to the first

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half of October, 1998 to December, 2000 and the second half of January 2001 to June 2004. This study performed simple statistical comparisons in forecasting accuracy and a formal test of differences in forecasting errors. The study has shown new records of price hikes unseen for last two decades. One of the reasons for this phenomenon could be the difficulty in forecasting crude oil prices. According to statistical results, WTI crude oil futures market turns out to be efficient relative to EIA experts’ system and econometric models. Consequently, WTI crude oil futures market could be utilized as a market-based tool for price forecasting and/or resource allocation.

34. Narayan and Narayan (2007) examined the volatility of crude oil price using daily data for the period 1991–2006 from Australia by Exponential GARCH (EGARCH) model. They found that across the various sub-samples, there was inconsistent evidence of asymmetry and persistence of shocks. And over the full sample period, evidence suggested that shocks have permanent effects and asymmetric effects, on volatility and the behaviour of oil prices tends to change over short periods of time.

35. Mastrangelo (2007) presented an analysis of price volatility in the spot natural gas market, with particular emphasis on the Henry Hub in Louisiana considering the Henry Hub spot price from 1994 to 2006. The purpose was to address whether natural gas prices have been more volatile in recent years and identify potential market factors that may contribute to price volatility.

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In addition to a first-order autoregressive error model, several graphical and statistical tools were used to examine trends and determine influencing factors. Although there was no demonstrated long-term trend in volatility, there were seasonal patterns and volatility was correlated strongly with storage dynamics.

36. **Cuaresma, Jumah and Karbuz (2007)**\(^{134}\) proposed a new time series model aimed at forecasting crude oil prices by concentrating around three marker crudes – WTI crude oil, NYMEX Brent and Dubai crude oil using monthly data for the period January, 1983-August, 2007. The proposed specification was an unobserved components model with an asymmetric cyclical component. The asymmetric cycle was defined as a sine-cosine wave where the frequency of the cycle depends on past oil price observations. The results of the study suggest that oil price forecasts improve significantly when this asymmetry was explicitly modeled.

37. **Marzo and Zagalia (2007)**\(^{135}\) studied the forecasting properties of linear GARCH models for closing-day futures prices on crude oil, first position, traded at NYMEX from January, 1995 to November, 2005. In order to account for fat tails in the empirical distribution of the series, they compared models based on the normal Student’s t and Generalized Exponential distribution. They focused on out-of-sample predictability by ranking the models according to a large array of statistical loss functions. The results from the

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tests for predictive ability showed that the GARCH-G model fares best for short horizons from one to three days ahead. For horizons from one week ahead, no superior model can be identified. They also considered out-of-sample loss functions based on Value-at-Risk that mimic portfolio managers and regulators’ preferences. EGARCH models display the best performance in this case.

38. Ying, Zhang, Tsai and Wei (2008)\(^{136}\) estimated volatility using GARCH-type models, based on the Generalized Error Distribution (GED), for both the extreme downside and upside Value-at-Risks (VaR) of returns in the WTI and Brent crude oil spot markets. They collected daily spot WTI and Brent crude oil prices from May, 20th in 1987 to August, 1st in 2006, which were quoted in US dollars per barrel by EIA, U.S. Furthermore, according to a new concept of Granger causality in risk, a kernel-based test was proposed to detect extreme risk spillover effect between the two oil markets. Results of an empirical study indicated that the GED-GARCH-based VaR approach appears more effective than the well-recognized HSAF (i.e. historical simulation with ARMA forecasts). WTI return appeared more volatile in some periods. During the Gulf War, volatility of the Brent return turns out to be sharper than that of the WTI return. The speed of decay of volatility shock in both WTI and Brent returns was very slow. They also found the volatility of the Brent return did not have a leverage

effect and WTI and Brent returns have significant two-way Granger causality in risk.

39. **Pigildin (2009)**\(^{137}\) evaluated the closing spot prices of WTI crude oil and Henry Hub natural gas spanning from 1994 to 2009. The VAR series obtained with this method were statistically accurate and were the least likely to result in forgone profits from speculation. This work examined the performance of four risk quantification methodologies (widely known as value at risk) and assesses them against several accuracy and efficiency criteria. The results indicated that at 95 percent confidence level GED-GARCH method were used further to investigate the extreme risk spillover between crude oil and natural gas markets perform better than any other alternative. They concluded that irrespective of whether oil or gas risk quantification and management in energy markets were an indispensable way of business survival and prosperity.

40. **Nian (2009)**\(^{138}\) studied daily NYMEX WTI crude oil prices volatility using the data obtained from EIA for the period from 2\(^{nd}\) January, 1986 to 30\(^{th}\) September, 2009. They used the Box-Jenkins methodology and GARCH approaches. GARCH(1,1) was found to be a better model than ARIMA (1,2,1) model. Based on the study, they concluded that GARCH (1,1) was the better model for daily crude oil prices due to its ability to capture the volatility by the non-constant of conditional variance.

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41. **Agnolucci (2009)**\(^{139}\) assessed the accuracy of the forecasting models on the basis of integrated volatility. They have estimated GARCH models by using daily returns from the generic light sweet crude oil future based on the WTI traded at the NYMEX. Data on the price of the contract have been sourced from the Bloomberg database for the period 31\(^{st}\) December, 1991 to 2\(^{nd}\) May, 2005. The results suggest that the mean return from oil futures can be assumed to be constant across time, although not statistically different from zero. Secondly, shocks to the conditional variance of the series have been found to be highly persistent. Thirdly, the parameters in the models were robust to the distribution assumed for the errors. In addition, no leverage effect can be observed in the oil future series.

42. **Liu, Chen, and Su (2011)**\(^{140}\) examined short term and long run relationships between the petroleum futures and spot prices. The data used in this study comprises of daily data on the closing spot and futures price of WTI sourced mainly from the databank of NYMEX from January 1, 2004 through September 30, 2009 and thus 1,500 observations. They used the TECM GJR-GARCH. The empirical result revealed that the petroleum spot and futures markets have interactive effect and there was information flow (transmission) between the two markets. Accordingly, the speculators, hedgers, and financial managers can obtain more insights into the management of their short run investing and hedging strategies on petroleum futures contracts.


43. Bakanova (2011)\textsuperscript{141} evaluated the information content of an option-implied volatility of the light, sweet crude oil futures traded at NYMEX. Dataset for this study contains daily time series of light, sweet crude oil futures and American-style options written on these futures which were traded at NYMEX for the period from January 2\textsuperscript{nd}, 1996 through December 14\textsuperscript{th}, 2006. This measure of volatility was calculated using model-free methodology that was independent from any option pricing model. They found that the option prices contain important information for predicting future re-analyzed volatility. They also found that implied volatility outperforms historical volatility as a predictor of future realized volatility and subsumes all information contained in historical data.

44. Salisu and Fasanya (2012)\textsuperscript{142} examined crude oil price volatility using daily data for the period from 4\textsuperscript{th} April 2000 to 20\textsuperscript{th} March 2012. They considered both the symmetric models GARCH(1,1) and GARCH-M (1,1)) and asymmetric models TGARCH(1,1) and EGARCH(1,1). One interesting innovation of the study was that it evaluated the volatility over three period namely pre-global financial crisis, global financial crisis and post-global financial crisis. They found that oil price was most volatile during the global financial crises compared to other sub samples. Based on the appropriate model selection criteria, the asymmetric GARCH models appear superior to the symmetric ones in dealing with oil price volatility. This finding indicated that evidence of leverage effects in the oil market


and ignoring these effects in oil price modeling would lead to serious biases and misleading results.

2.5 *Empirical Studies on Long and Short Term Relationship between Energy Commodities and Other Commodities / Parameters*

45. **Huang, Masulis and Stoll (1996)**\(^{143}\) were of the opinion that crude oil price volatility is having an important real effect on the U.S. economy. If such an effect was presented, returns in oil futures should affect aggregate stock returns. They examined the contemporaneous and lead-lag correlations between daily returns of oil futures contracts and stock returns. The association between oil volatility and stock market volatility was also investigated. Surprisingly, in the period of the 1980s, there was virtually no correlation between oil futures returns and the returns of various stock indexes. In the case of specific oil stocks, there was contemporaneous correlation and a statistically significant one day lead of oil futures returns. However the economic significance of the lead was small. A simple bivariate correlation of raw returns produces the same conclusions as a more sophisticated multivariate VAR approach.

46. **Beckmann and Czudaj (2002)**\(^{144}\) analyzed the link between oil prices and dollar exchange rates. Monthly dataset including the oil price and consumer price index of USA as the foreign country as well as the CPI’s of ten different states regarded as domestic countries. Their sample starts right after the occurrence of a major oil price shock due to the Arab oil embargo in 1973/74 and the breakdown of Bretton Woods. They considered Russia,

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Mexico, Canada, Norway, and Brazil as the major oil-exporting countries as well as the Euro Area, Japan, South Africa, Sweden and the UK as oil-importing countries and use their nominal exchange rates against the U.S. dollar. They concluded that in nominal terms, a rise of the oil prices coincided with an appreciation of the dollar against the Japanese yen, the British pound, the Norwegian krone, the Mexican peso and the South African rand. For Russia, Brazil, Canada, the Euro Area and Sweden a nominal appreciation can be observed. Hence, a pattern of nominal appreciation against the dollar can mostly be observed for oil exporting countries while the nominal depreciation was detected for importing and other exporting countries.

47. Shawkat, Diboogl and Aleisa (2004)\textsuperscript{145} suggested that the pure oil industry equity system and the mixed oil price/equity index system offered more opportunities for long-run portfolio diversification and less market integration than the pure oil price systems. On a daily basis, in the oil price systems all oil prices with the exception of the 3-month futures could explain the future movements of each other. In the mixed system, none of the daily oil industry stock indices could explain the daily future movements of NYMEX futures prices, whereas these prices can explain the movements of independent companies engaged in exploration, refining, and marketing. The day effect for volatility transmission suggested that Friday has a calming effect on the volatility of oil stocks in general. The effect for Monday was not significant.

48. Chen, Finney and Lai (2005)\textsuperscript{146} studied long term and short term relationship of spot markets of crude oil and refinery gasoline but also through their future markets. They used the threshold error-correction model. The data from overlapping future contracts were compiled, with rollover to the next contract in the first week of each month. The retail prices were national averages for self-serve regular unleaded gasoline reported by the EIA weekly Motor Gasoline Price Survey. The sample data cover the period January, 1991 through March, 2003. The start date of the sample was dictated by the availability of the EIA survey data on retail prices. Evidence showed that the observed asymmetry in price transmission primarily occurred downstream – not upstream – of the transmission process. They found this evidence in short and long term adjustment and also across the spot and futures markets.

49. Cunado and Gracia (2005)\textsuperscript{147} studied the oil prices vs. macro economy relationship by means of studying the impact of oil price shocks on both economic activity and consumer price indexes for six Asian countries (Japan, Singapore, South Korea, Malaysia, Thailand and Philippines) over the period from 1\textsuperscript{st} quarter of 1975 to 2\textsuperscript{nd} quarter of 2002. They used the GARCH(1,1) model. The results suggested that oil prices have a significant effect on both economic activity and price indexes, although the impact was limited to the short run and more significant when oil price shocks were defined in local currencies.


50. Alizadeh, Nomikos and Pouliaisis (2008) investigated the hedging effectiveness of the Markov Regime Switching (MRS) models for NYMEX WTI crude oil futures contracts. The data set for this study comprised weekly spot and futures prices for three energy commodities traded on NYMEX: WTI crude oil, unleaded gasoline and heating oil, covering the period January 23, 1991 to December 27, 2006, resulting 832 weekly observations. They introduced MRS VECM with GARCH error structure. This specification linked the concept of disequilibrium with that of high uncertainty across high and low volatility regimes. The results indicated that using MRS models, market agents may be able to obtain superior gains, measured in terms of both variance reduction and increase in utility.


that were not statistically significantly different from either zero or from the relationships of the previous period. The expected negative long-run relationship appears to disintegrate after September 1999. This finding supported a conjecture of change in the relationship between real oil price and real stock prices in the last decade compared to earlier years. This suggests the presence of several stock market bubbles and/or oil price bubbles since the turn of the century.

52. Ripple and Moosa (2009)\textsuperscript{150} analyzed the relationship between the volatility of futures prices and the maturity of contracts, trading volume, and open interest. The concept of open interest was introduced to find out whether or not this additional measure of market activity was useful for explaining volatility. The daily crude oil futures data were sourced directly from the NYMEX for the period January, 1995 to December, 2005. They examined the relation on a contract-by-contract basis or via time series analysis over an eleven year period, open interest contributed significantly to the explanation of futures volatility for the NYMEX crude oil contract.

53. Papapetrou (2009)\textsuperscript{151} studied the relationship between oil prices and economic activity in Greece during the period 1\textsuperscript{st} January, 1982 to 31\textsuperscript{st} August, 2008. They used regime-switching model (RSR) and a threshold regression modeling (TA-R) to estimate whether oil price changes affect asymmetrically the economic activity. These models have the advantage to


capture the dependence structure of the series both in terms of constant and variance. The empirical evidence suggested that the degree of negative correlation between oil prices and economic activity strengths during periods of rapid oil price changes and high oil price change volatility.

54. Hamilton and James (2000)\textsuperscript{152} examined oil price volatility from 2003 and mid-2008 driven by global demand shocks, whereas earlier oil price shocks were primarily driven by exogenous oil supply shocks in the Middle East. They used the GARCH(1,1). Though, this interpretation was not consistent with a wide range of evidence, however, it indicated a central role for oil demand shocks in all previous oil price shock episodes since 1972 except the oil price shock triggered by the outbreak of the Iran-Iraq war in late 1980. They concluded that movements in oil prices affect exchange rates.

55. Wang, Ping and Huang (2010)\textsuperscript{153} used daily data and time series method to explore the impacts of fluctuations in crude oil price, gold price, and exchange rate of the US dollar vs. various currencies on the stock price indices of the United States, Germany, Japan, Taiwan and China respectively, as well as the long and short-term correlations among these variables between January, 2006 to February, 2009. Empirical results showed that there existed co-integration among fluctuations in oil price, gold price and exchange rates of the dollar vs. various currencies and the stock markets in Germany, Japan, Taiwan and China. They indicated that there exist long-term stable relationships among these variables. Whereas


there was no co-integration relationship among these variables and the U.S. stock market indices which indicated that there was no long-term stable relationship among the oil price, gold price and exchange rate and the US stock market index. In addition, empirical results of the causal relation showed that in Taiwan, for example, oil price, stock price and gold price have two-way feedback relations.

56. Fattouh (2010)\textsuperscript{154} studied the WTI, Dubai, Brent and Brent-Dubai crude oil price differentials which were modeled as a two-regime threshold autoregressive (TAR) process during 1994 to 2008. While standard unit root tests suggested that the prices of crude oil of different varieties move closely together such that their price differential was stationary, the TAR results indicated strong evidence of threshold effects in the adjustment process to the long-run equilibrium. These findings suggested that crude oil prices were linked and thus at the very general level, the oil market was ‘one great pool’. However, differences in the dynamics of adjustment suggested that within this one pool, oil markets were not necessarily integrated in every time period and hence the dynamics of crude oil price differentials may not follow a stationary process at all times.

57. Burçak (2010)\textsuperscript{155} studied six non-ferrous metals (aluminum, copper, lead, nickel, tin, and zinc) to assess the forecasting performance of GARCH models. In order to move as far away from the effects of 9/11, daily data for the period from December 12, 2003 to December 15, 2008 was used for the


data analysis. They found that the forecasting performances of GARCH, EGARCH and TGARCH models were similar. However, they suggested the use of the GARCH model because it was more parsimonious and has a slightly better statistical performance than the other two. In the second part, the prices of six non-ferrous metals and the price of crude oil were used to examine the dynamic links between oil and metal returns by using the BEKK specification of the multivariate GARCH model and the Granger causality-in-variance tests. Results of their study agreed with the previous studies in that the crude oil market volatility leads all non-ferrous metal markets.

58. Zhang and Wei (2010)\textsuperscript{156} examined cointegration and causality, and investigate their respective contribution, from the perspective of price discovery, to the common price trend so as to interpret the dynamics of the whole large commodity market and forecast the fluctuation of crude oil and gold prices with significant positive correlation coefficient of 0.9295 during the sampling period from January 2000 to March 2008 from China. Second, there can be seen a long-term equilibrium between the two markets and the crude oil price change linearly Granger causes the volatility of gold price, but not vice versa. Moreover, the two market prices faced a significant nonlinear Granger causality, which overall suggested their fairly direct interactive mechanism. Finally, with regard to the common effective price between the two markets, the contribution of the crude oil price seems larger than that of the gold price, which implies that the influence of crude

oil on global economic development proved more far-reaching and extensive, and its role in the large commodity markets has attracted more attention in recent years.

59. Simakova (2010)\textsuperscript{157} focused on the relationship between oil and gold prices with a focus on analyzing and determining the character of the co-movement between price levels using the monthly average price data from 1970 to 2010. They used WTI crude oil price quoted in dollars per barrel in the Federal Reserve Economic Data portal. The price of gold was listed in dollars per troy ounce which were collected from Kitco website. With 491 available observations in total, the data were analyzed using Granger causality test, Johansen’s co-integration test and Vector Error Correction model. They concluded that existence of a long-term relationship between analyzed variables.

60. Ghaith and Awad (2011)\textsuperscript{158} attempted to investigate long-term relationship between the prices of crude oil and food commodities represented by maize, wheat, sorghum, soybean, barley, linseed oil, soybean oil and palm oil. Time series econometric techniques such as unit root tests, co-integration, and Granger causality were applied. The study utilizes monthly data over the period from April, 1980 to March, 2009. The results of this study revealed that there was a strong evidence of long-term relationship between crude oil and the food commodity prices. A


traditional Granger causality was used to check whether causality exists between two product prices. The outcome suggested that there was unidirectional causality between the price of crude oil and some of the food commodities examined.

61. **Le and Chang (2011)** investigated the relationship between the prices of two strategic commodities viz gold and oil in USA, using the monthly data spanning from January, 2004 to April, 2004 with total of 304 observations for each series. They used the pair wise Granger causality analysis, VAR and Regression. Different oil price proxies were used for their investigation and found that the impact of oil price on the gold price was not asymmetric but non-linear. Further, results showed that there was a long-run relationship existing between the prices of oil and gold. The findings implied that the oil price can be used to predict the gold price.

62. **Ojebiyi and Wilson (2011)** assessed the existence of correlation between exchange rate of Nigerian Naira and Unites States dollar and oil price on the basis of monthly data from 1999 to 2009 using fundamental variables viz., the monthly spot crude oil price, monthly exchange rate of Nigeria Naira and monthly exchange rate of U.S. Dollar. The empirical result adopted the ordinary least square using regression analysis and also the correlation model. It is identified that there was a weak/negative relationship between exchange rate and oil price as there were other factors that brings about changes in oil price other than the exchange rate.

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The study also pointed out that the activities of cartel pricing policy and oil speculators too have come to greatly affect the price of crude oil.

2.6 Empirical Studies in Energy Commodities with Focus on Indian Markets:

63. Khan and Salman (2010)\textsuperscript{161} investigated the relationship between the crude oil and the stock market in terms of returns and volatility-spillover for the BRIC countries by using co-integration and the VECM-MGARCH technique. The data was obtained from Data Stream for the period from 2\textsuperscript{nd} February 2003 to 31\textsuperscript{st} March 2010 as daily closing prices. The total number of observation for each index was 1870. The data consisted of Brent crude oil price basket, Bolsa Oficial de Valores de Sao Paula (BOVESPA Index), Russian Trading System (RTS Index), Bombay Stock Exchange (BSE Sensex Index) and Shanghai Stock Exchange (SSE Composite Index). The results revealed that the oil and the market returns were co-integrated in all the markets. The results from VECM indicated stable, bidirectional, long-run relationship between oil prices and market returns while short-run linkages were found to be absent in all the cases except Russia where it significantly affects the Brent prices. They found that overall BRICs have strong, stable, bidirectional and long-term relationship with the Brent price index. They also studied the volatility spillover effects and found that BRICs equity markets were highly interconnected with crude oil market where shocks and spillover were found to be significant and bidirectional.

64. **Pushpa, Chakraborty and Mathur (2011)** investigated the existence of long-term relationships between oil prices and stock market prices of two big emerging countries of Asia, India and China. Since India and China were the major oil consuming market, their stock markets were likely to be susceptible to oil price fluctuations. A data series from January, 2000 to May, 2011 was considered. The stationarity of the data series were checked using ADF test. Johansen co-integration model was applied to find out the co-integration among the oil prices and stock prices of India and China. At last the VECM was employed to trace the existence of long run relationship between the variables. The results of the co-integration analysis depicted long run relationship between oil prices and stock market prices for both the countries. The Trace and maximum Eigen value tests results also revealed the existence of unique co-integrating vectors between test variables. This provided evidence on the existence of at least one co-integrating vector in the model and therefore it could be concluded that the variables exhibit a long-run association between them.

65. **Chittedi (2011)** investigated long run relationships between oil prices and stock prices in India for the period April, 2000 to June, 2011. The oil price data was collected from Petroleum Planning & Analysis Cell, Ministry of petroleum, Government of India, where as BSE and NSE stock prices were collected from respective websites. They employed autoregressive

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distributed lag (ARDL) approach test to explore the long-run and short relationships. The results projected India’s aggressive economic growth in the past fifteen years, and the volatility of stock prices in India have a significant impact on the volatility of oil prices and change in the oil prices had impact on stock prices.

66. **Bhunia and Mukhuti (2012)** examined the short-term and long-term relationships between BSE 500, BSE 200 and BSE 100 Indices of Bombay Stock Exchange and crude oil price by using Johansen’s co-integration test, VECM and Granger causality test. The study covered the period from 2nd April, 2001 to 31st March, 2011. With data consisting of 2496 days. The empirical results shown there was a co-integrated long-term relationship between three index and crude oil price. Granger causality results reveal that there was one way causality relationship from all index of the stock market to crude oil price, but crude oil price was not causal to each of the three indices.

67. **Sharma, Singh, Manisha and Gupta (2012)** analyzed effects of crude oil prices on Indian economy. They collected the oil data from 1970 to 2012 and employed the Trend Analysis. The immediate effect of the oil price shock was the increased cost of production due to increased fuel cost. Whenever there was an over inflation in the economy, the cost of production would also rise causing a decrease in supply. On the other

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hand, inflation implies a fall in the purchasing power of people. In short, oil price fluctuation has adverse effects on the economy.

68. **Goyal and Tripathi (2012)** assessed the role of fundamentals compared to liquidity and innovation driven expansion in net long positions, and the effect of integration across exchanges. Data was taken over February, 2005 to June, 2010, since this was a period of high volatility in oil prices and MCX commenced trading in crude oil futures on February 9, 2005. The dataset included US WTI crude oil spot prices, UK Brent spot, MCX WTI spot, monthly or daily close nearby futures prices on the three commodity exchanges. They used first test for mutual Granger causality and lead-lags in vector error correction models (VECM), between crude oil spot and nearby futures prices on two international and one Indian commodity exchange. If futures were found to affect spot, but not vice versa, it could support the dominance of expectations mediated through financial markets on prices. There was mutual Granger causality between spot and futures, and in the error correction model for mature exchanges, spot leads futures. Mature market exchanges lead in price discovery. But there was stronger evidence of short-term or collapsing bubbles in mature market futures compared to Indian market, although mature markets have a higher share of hedging. Indian regulations such as position limits may have mitigated short duration bubbles. Further they suggested that well-designed regulations could improve the functioning of the market.

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69. **Sharma and Khanna (2012)**\(^{167}\) analyzed the reaction of the stock market towards the crude oil price changes. The study was based on the daily percentage changes in oil prices and percentage changes in daily market returns as per the stock market indices from 2008 to 2011. For this they considered mainly three stock markets viz., NYSE, BSE, and LSE representing USA, India and UK respectively. To judge the impact of crude oil price changes on stock market, the study focused on establishing the relationship between the market returns and oil prices. The study has taken the percentage changes in the figures of both variables. For this purpose, tools such as correlation, regression, and coefficient of determination were used through SPSS statistical software. They found that the NYSE & LSE returns were more relatively affected by the oil prices during the period than Indian BSE market. As the study period also covered the crucial period of recession, Euro zone financial crisis and some other political imbalances, the NYSE and LSE markets have reacted very rapidly towards such events.

70. **Kumar and Pandey (2012)**\(^{168}\) analyzed the cross market linkages in terms of return and volatility spillovers in nine commodities consisting of two agricultural commodities: Soybean, and Corn, three metals: Aluminum, Copper and Zinc, two precious metals: Gold and Silver, and two energy commodities: Crude oil and Natural gas. For agricultural commodities daily prices of near month futures contracts from NCDEX and for non-


agricultural commodities daily prices of near month futures contracts traded on MCX were used. Return spillover was investigated through Johansen’s co-integration test, error correction model, and Granger causality test and variance decomposition techniques. They used Bivariate GARCH model (BEKK) to investigate volatility spillover between India and other world markets. They found that futures prices of agricultural commodities traded at NCDEX and CBOT, prices of precious metals traded at MCX and NYMEX, prices of industrial metals traded at MCX and LME, and prices of energy commodities traded at MCX and NYMEX were co-integrated. Results of return and volatility spillovers indicated that the Indian commodity futures markets function as a satellite market and assimilate information from the world market.

71. **Tandon, Abuja and Neelamtandon (2012)**\(^{169}\) established the effect of price movements in the futures / derivative market of Brent crude oil on the prices of shares of the companies involved in the exploration and extraction of oil and natural gas and was listed on Indian stock markets. The crude oil futures and the spot prices of oil production companies had been collected from NSE, MCX, and NCDEX. The data for the study was the value of future contract of Brent crude and the spot prices of the 2 upstream companies which were Oil and Natural Gas Corporation (ONGC) and Gas Authority of India Limited (GAIL) and 2 downstream companies which were Hindustan Petroleum Corporation Limited (HPCL)

and Indian Oil Corporation Limited (IOCL). The near month futures contracts were found to have the maximum influence on the spot prices of the markets. The lead-lag relationship between spot prices and the near month contract prices was then found using cross correlations and Granger causality test. Co-integration was performed for the purpose of confirming the co-integration of the variables analyzed. The results indicated that crude oil futures variation has the maximum effect on the spot prices of shares of energy sector companies and a lag period of 16 days is the most appropriate prediction time which influences present day's spot prices of shares of downstream oil and natural gas exploration companies. The spot prices of upstream energy sector companies were not affected by the futures contract of Brent crude.

2.7 Research Gap:

To summarize, although the body of oil and natural gas literature is substantial, most of the earlier studies were concentrating on U.S. energy commodity derivatives market especially the NYMEX. Further, most of the studies on U.S. markets concentrated on WTI crude oil and Hunry hub natural gas. There is still substantial gap in literature relating to studies pertaining to a comparative study on long and short term relationship of Indian market and U.S. markets. This is particularly the case in the relation between spot prices between crude oil and natural gas. While most studies agree on the importance of futures prices for financial markets, only a few studies, if any, agree on how, and why it is important. The relation between futures and spot price has been the center of attention for a large number of studies, and the literature is rich with several studies covering a range of aspects with respect to this relationship. Lead-lag, efficiency, price prediction is the
most studied areas in futures-spot literature\textsuperscript{170}. Most studies on international linkages across spot and futures markets of the same underlying suggest that there are stronger international market linkages in highly traded commodities like crude oil as compared to relatively less traded commodities especially in natural gas. Moreover, the developed markets with large volume play dominant role in price discovery process. Although the body of literature is substantial related to crude oil and natural gas, there is still a great deal of inconsistency in the findings. This is particularly the case in the relation between spot prices\textsuperscript{171}.

Given the research gap on International linkages of spot markets in emerging markets, this research work attempts to investigate the cross-market linkages of Indian crude oil and natural gas spot market with developed world market viz. the U.S. oil and gas market. From the reviews of earlier research focused on crude oil and natural gas markets, we could able to figure out that research studies on analyzing the relationship between Crude Oil and Natural Gas spot prices in a developing economy like India is not yet attempted. Hence, the present study \textit{“Estimating Relationship and Forecasting volatility & Spot Price of Crude Oil and Natural Gas in India and USA”} attempts to fill the research gap by focusing mainly to determine the existence of long term and short term relationship between Indian and U.S. spot prices of crude oil & natural gas and the possibility of forecasting Volatility and spot prices. More specifically this study attempts to contribute to the empirical analysis on ascertaining the causal relationship (short term)
and co-integration (long term) between crude oil & natural gas spot markets. Further, in
despite of several research findings which highlighted the importance and usefulness of
GARCH(1,1) model for forecasting of spot prices, there is sparse empirical research on
Indian crude oil & natural gas markets using this model. The study will also attempt to
contribute in terms of specifying an appropriate model to forecast volatility and spot price
using the econometric tool GARCH(1,1).

2.8 Concluding remarks:

After having reviewed the methodologies and approaches pursued in the earlier
researches pertaining to crude oil and natural gas markets, in the next chapter, we proceed
with furnishing details of the data sets and methodology adopted in the present study for
determining the nature of relationship and the possibility of forecasting U.S. and Indian
crude oil and natural gas spot prices.