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"Arbitrage in International pricing and its implication in Energy Trading"

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In partial fulfillment of the requirements for the award of the Degree of
Master of Business Administration in Energy Trading

By

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Under the guidance of
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DECLARATION

I, Upasana Singh, student of MBA (Energy Trading) hereby declare that the project titled "Arbitraging in International Pricing and its Implication in Energy Trading" which is submitted by me to Department of Oil and Gas, College of Management and Energy Studies, Dehradun, in partial fulfillment of requirement for the award of the degree of Master of Business Administration in Energy Trading, has not been previously formed the basis for the award of any degree, diploma or other similar title or recognition.

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BONAFIDE CERTIFICATE

This is to certify that Ms. Upasana Singh, student of University of Petroleum and Energy Studies, Dehradun, pursuing MBA (Energy Trading), has successfully completed her dissertation project. As a part of her curriculum, the project report titled, "Arbitrage in International Pricing and its Implication in Energy Trading" submitted by the student to the undersigned is an authentic record of her original work which she has carried out under my supervision and guidance. This study has not been submitted anywhere else for degree purpose.

I wish her all the best.

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Singh 21/4/04

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Abstract

This paper investigates the cross market linkages of Indian crude futures with futures markets outside India. We have analyzed the cross market linkages in terms of return and volatility spillovers. The two exchanges taken into consideration are MCX and NYMEX, MCX being the domestic exchange and NYMEX being the international exchange. Return spillover is investigated through Johansen's cointegration test, error correction model, Granger causality test and variance decomposition techniques. We find that futures prices of crude oil traded at Multi Commodity exchange, India (MCX) and New York Mercantile Exchange (NYMEX), are cointegrated. It is found that global market has bigger (unidirectional) impact on Indian markets. In bivariate model, we found bi-directional return spillover between MCX and NYMEX markets. However, effect of NYMEX on MCX is stronger than the effect of MCX on NYMEX. Results of returns indicate that the Indian energy futures market function as a satellite market and assimilate information from the global market.

Keywords: International linkage, Arbitraging, Cross market linkages

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1. INTRODUCTION

1.1 Arbitrage: An Overview

Billingsley (2005) explains arbitrage as the process of buying assets in a market and selling them in another to make profit from unjustifiable price differences. This violates the expectation that the same product should sell for the same price in all the markets. Arbitrage offers guaranteed profit with practically no risk, and therefore undermines the stability and functionality of the markets.

Arbitrage occurs due to the market imperfections which gives arbitragers a chance to make profit when, there exists a disparity in different markets. Let's have a look at the economic aspect of the concept of purchasing power, we find that the commodity arbitrage view holds good i.e. in integrated world market, prices are geographically arbitraged, so that identical products sell for the same common- currency price in different markets/locations. Thus, the law of one price holds for every good.

1.2 Law of One Price

The law of one price exists due to arbitrage opportunities. If the price of a security, asset or commodity is different in two different markets, then an arbitrageur will purchase the commodity/asset in the cheaper market and sell it where the prices of the commodity are higher. When the purchasing power parity doesn't hold, arbitrage profits will persist until the price converges across those markets.

Now let us see the crude oil futures, to explain the relationship between the different crude oil futures in the different markets we need to understand a few concepts like backwardation and contango.

Backwardation is that market condition in which futures price is lower than the spot price for a specific commodity. For crude oil, Litzenberger and Rabinowitz (1995) observe that oil futures prices are often backwardated; specifically they find that strong backwardation, that is, futures price less than the spot price, occurs approximately 77% in oil futures markets, while weak backwardation, that is, discounted oil futures price less than the spot price, occurs 94% of the time over the period of February 1984 through April 1992. Knetsch (2007) also confirms Litzenberger and Rabinowitz (1995) observation, that crude oil market is weakly backwarded in most cases.

Two of the most important functions of futures markets are:

a) Risk Management
b) Price Discovery

Futures markets perform risk allocation function whereby futures contracts can be used to lock-in prices instead of relying solely on the spot price movements which are uncertain in nature. Price discovery is the process by which information is assimilated in a market and price converges towards the efficient price of the underlying commodity.

In financial economic literature, the price discovery function of futures market has been studied in two broad contexts:

a) Return and volatility spill- over between spot and futures of an asset, and

b) International linkages or return and volatility spillover across different futures markets (across countries).

Origin of market linkages lies in the efficient market hypothesis which states that all the markets incorporate any new information simultaneously and there does not exists any lead-lag relationship across the markets. However, frictions in markets, in terms of transaction costs and information asymmetry, may lead to return and volatility spillovers between these markets. Moreover, all the markets do not trade simultaneously for many commodities. Understanding information flow across the markets is very important for hedge funds, portfolio managers and hedgers for hedging and devising cross-market investment strategies.

The study will analyse the gap present in the different markets which leads to market imperfections giving rise to the opportunity of arbitraging. As discussed earlier, the law of one price gives rise to arbitraging, due to which the price differences of the same commodity in the different markets, are taken advantage of in the two different markets.

1.3 History of Crude Oil:

Like prices of other commodities, the price of crude oil experiences wide price swings in times of shortage or oversupply. The crude oil price cycle may alter over several years responding to changes in demand as well as supply by OPEC and non-OPEC. We will discuss the impact of geopolitical events, supply, demand and stocks as well as NYMEX trading and the economy.

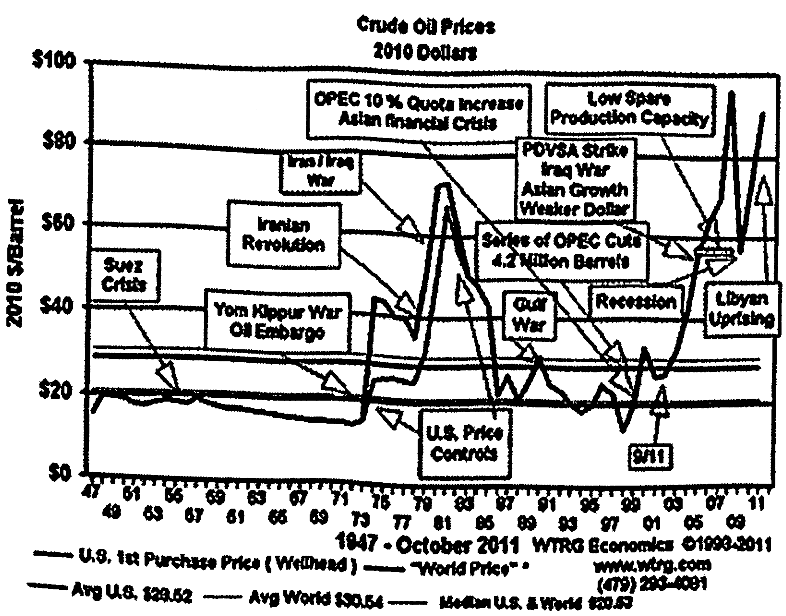
Throughout much of the twentieth century, the price of U.S. petroleum was heavily regulated through two means majorly:

A) Production

B) Price controls

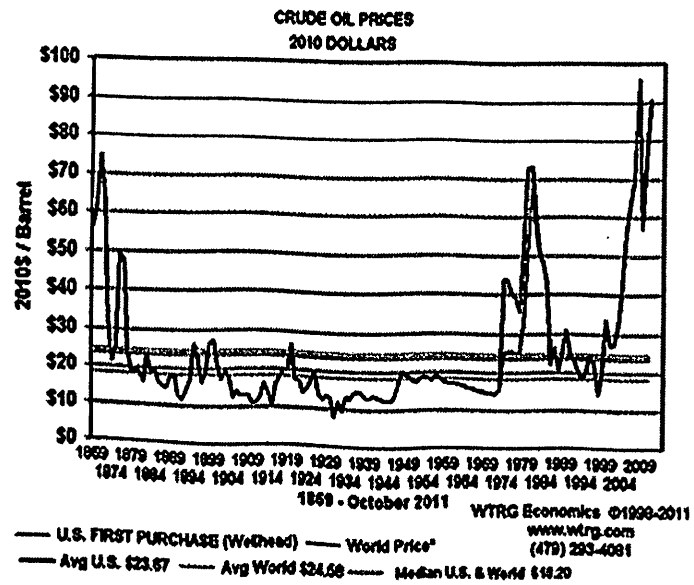
1.3.1 Post-World War II era: U.S. oil prices at the well-head averaged $28.52 per barrel adjusted for inflation to 2010 dollars. In the absence of price controls, the U.S. price would have tracked the world price averaging near $30.54. Over the same post war period, the median for the domestic and the adjusted world price of crude oil was $20.53 in 2010 prices. Adjusted for inflation, from 1947 to 2010 oil prices only exceeded $20.53 per barrel 50 percent of the time.

Figure 1: Factors involved in Crude oil price fluctuations



Until March 28, 2000 when OPEC adopted the $22-$28 price band for the OPEC basket of crude, real oil prices only exceeded $30.00 per barrel in response to war or conflict in the Middle East. With limited spare production capacity, OPEC abandoned its price band in 2005 and was powerless to stem a surge in oil prices, which was reminiscent of the late 1970s. Since 1869, US crude oil prices adjusted for inflation averaged $23.67 per barrel in 2010 dollars compared to $24.58 for world oil prices. Fifty percent of the time prices U.S. and world prices were below the median oil price of $24.58 per barrel. Considering long-term history as a guide, the upstream segment of the crude oil industry should structure their business to be able to operate with a profit, below $24.58 per barrel half of the time. The very long-term data and the post-World War II data suggest a "normal" price far below the current price. However, the rise of OPEC, which replaced the Texas Railroad Commission as the monitor of spare production capacity, together with increased interest in oil futures as an asset class introduced changes that support prices far higher than the historical "norm."

Figure 2: Comparison of Crude Oil Prices



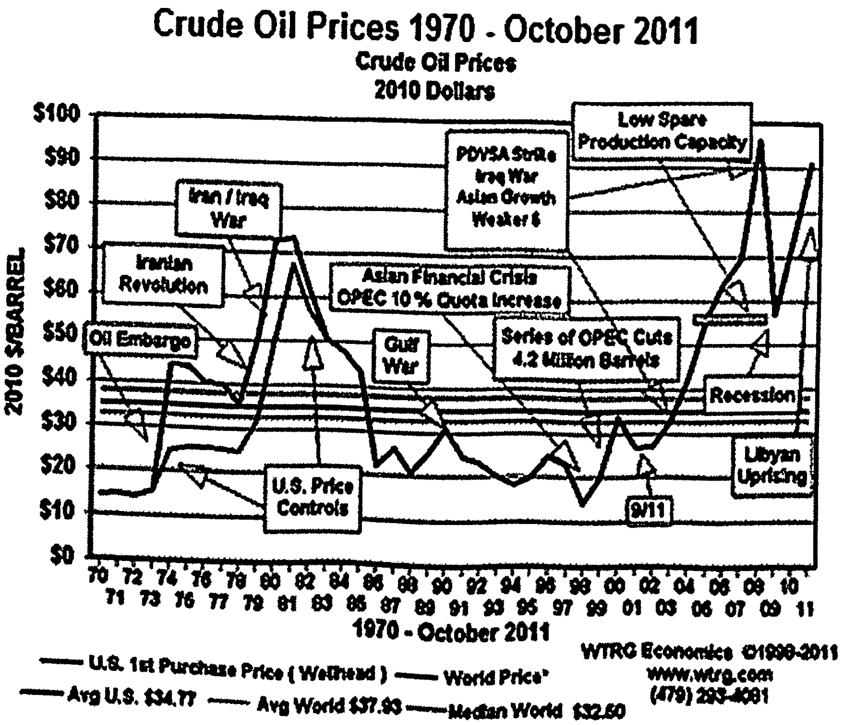
The results are dramatically different if only post-1970 data are used. In that case, U.S. crude oil had an average price of $34.77 per barrel. The more relevant world oil price averaged $37.93 per barrel. The median oil price for that period is $32.50 per barrel.

If oil prices revert to the mean this period is a little more appropriate for today's analyst. It follows the peak in U.S. oil production eliminating the effects of the Texas Railroad

Commission which effectively controlled oil prices prior to 1970. It is a period when the Seven Sisters were no longer able to dominate oil production and prices and an era of greater influence for OPEC oil producers. As we will see in the detail below, influence over the price of oil is not equivalent to control.

Prices in the mid $30s seem exceptionally low by today's standards. However, when the current President of the United States took office the price was $35.00 per barrel. By the end of 2009 prices had doubled bringing the average for 2009 to $56.35 or $57.00 in 2010$.

Figure 3: Crude Oil Prices from 1970 to 2011



Post-World War II:

A) **Pre-Embargo Period:** From 1948 through the end of the 1960s, crude oil prices ranged between $2.50 and $3.00. The price oil rose from $2.50 in 1948 to about $3.00 in 1957. When viewed in 2010 dollars, a different story emerges with crude oil prices fluctuating between $17 and $19 during most of the period. The apparent 20% price increase in nominal prices just kept up with inflation.

From 1958 to 1970, prices were stable near $3.00 per barrel, but in real terms the price of crude oil declined from $19 to $14 per barrel. Not only was price of crude lower when adjusted for inflation, but in 1971 and 1972 the international producer suffered the additional effect of a weaker US dollar.

OPEC was established in 1960 with five founding members: Iran, Iraq, Kuwait, Saudi Arabia and Venezuela. Two of the representatives at the initial meetings previously studied the Texas Railroad Commission's method of controlling price through limitations on production. By the end of 1971, six other nations had joined the group: Qatar, Indonesia, Libya, United Arab Emirates, Algeria and Nigeria. From the foundation of the Organization of Petroleum Exporting Countries through 1972, member countries experienced steady decline in the purchasing power of a barrel of oil.

Throughout the post war period exporting countries found increased demand for their crude oil but a 30% decline in the purchasing power of a barrel of oil. In March 1971, the balance of power shifted. That month the Texas Railroad Commission set proration at 100 percent for the first time. This meant that Texas producers were no longer limited in the volume of oil that they could produce from their wells. More important, it meant that the power to control crude oil prices shifted from the United States (Texas, Oklahoma and Louisiana) to OPEC. By 1971, there was no spare production capacity in the U.S. and therefore no tool to put an upper limit on prices.

A little more than two years later, OPEC through the unintended consequence of war obtained a glimpse of its power to influence prices. It took over a decade from its formation for OPEC to realize the extent of its ability to influence the world market.

Figure 4: World Events and Crude Oil Prices 1947-1973

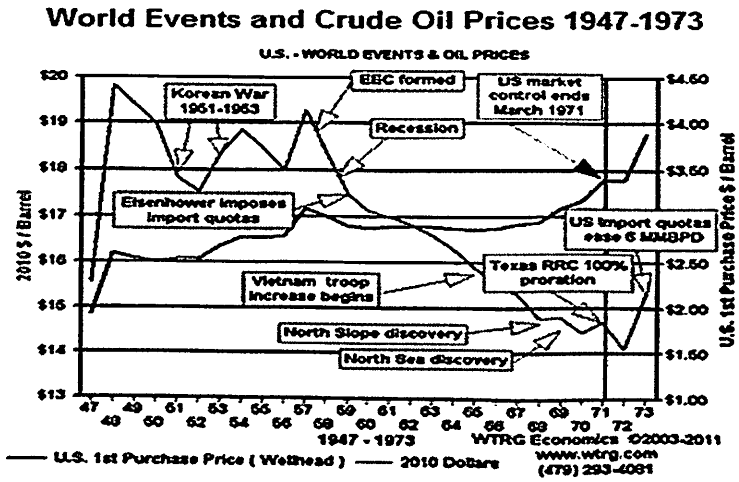
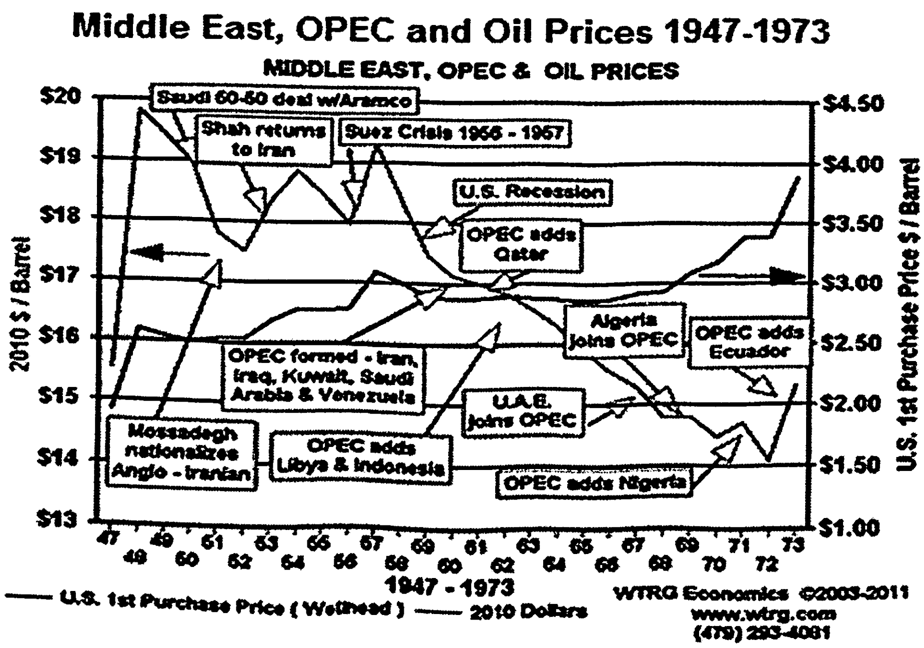


Figure 5: Middle East, OPEC and Oil Prices 1947-1973



B) Middle East Supply Interruptions:

Yom Kippur War- Arab Oil Embargo:

In 1972, the price of crude oil was below $3.50 per barrel. The Yom Kippur War started with an attack on Israel by Syria and Egypt on October 5, 1973. The United States and many countries in the western world showed support for Israel. In reaction to the support of Israel, several Arab exporting nations joined by Iran imposed an embargo on the countries supporting Israel. While these nations curtailed production by five million barrels per day, other countries were able to increase production by a million barrels. The net loss of four million barrels per day extended through March of 1974. It represented 7 percent of the free world production. By the end of 1974, the nominal price of oil had quadrupled to more than $12.00.

Any doubt that the ability to influence and in some cases control crude oil prices had passed from the United States to OPEC was removed as a consequence of the Oil Embargo. The extreme sensitivity of prices to supply shortages, became all too apparent when prices increased 400 percent in six short months.

From 1974 to 1978, the world crude oil price was relatively flat ranging from $12.52 per barrel to $14.57 per barrel. When adjusted for inflation world oil prices were in a period of moderate decline. During that period OPEC capacity and production was relatively flat near 30 million barrels per day. In contrast, non-OPEC production increased from 25 million barrels per day to 31 million barrels per day.

Figure 6: U.S. and World Events and Oil Prices 1973-1981

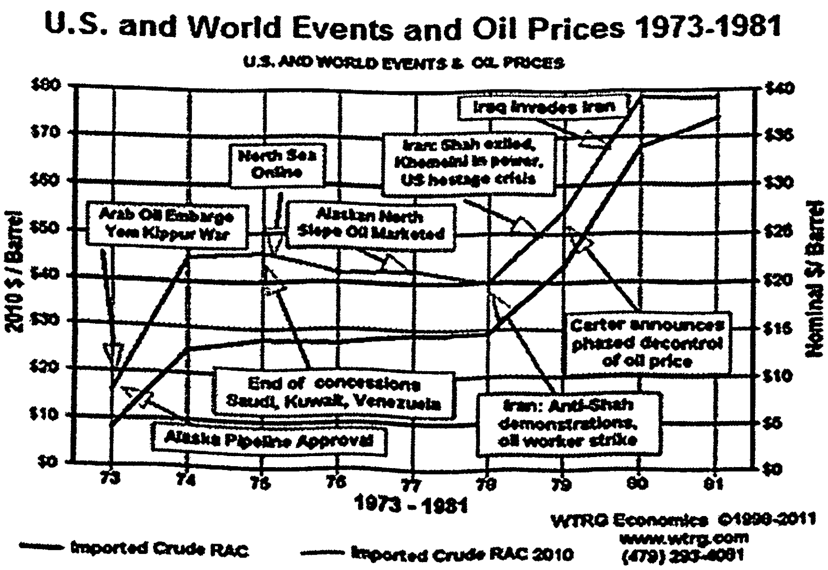


Figure 7: OPEC Oil Production 1973-June 2011

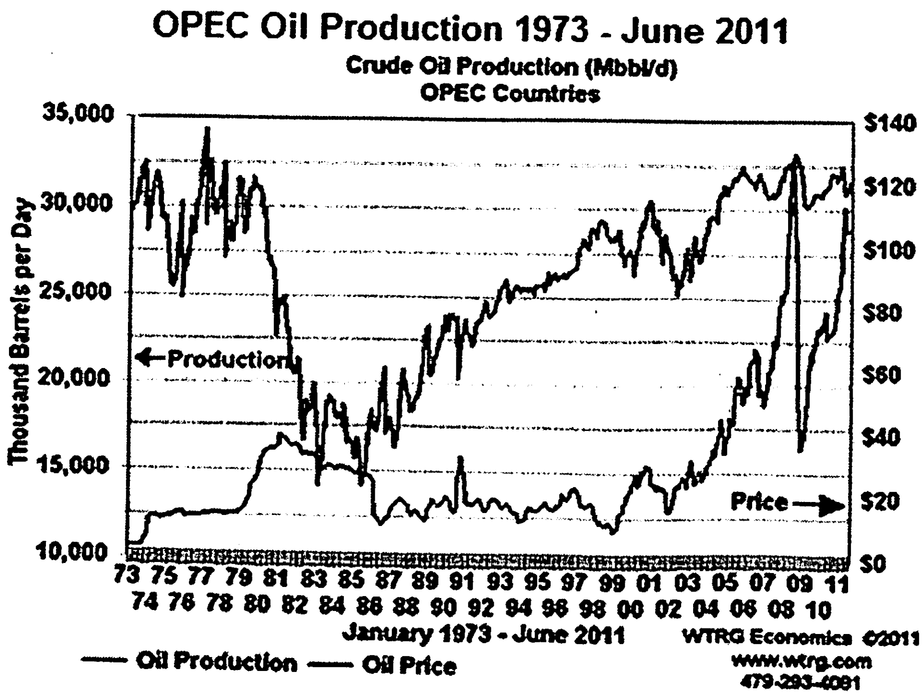


Figure 8: Non-OPEC Oil Production 1973-June2011

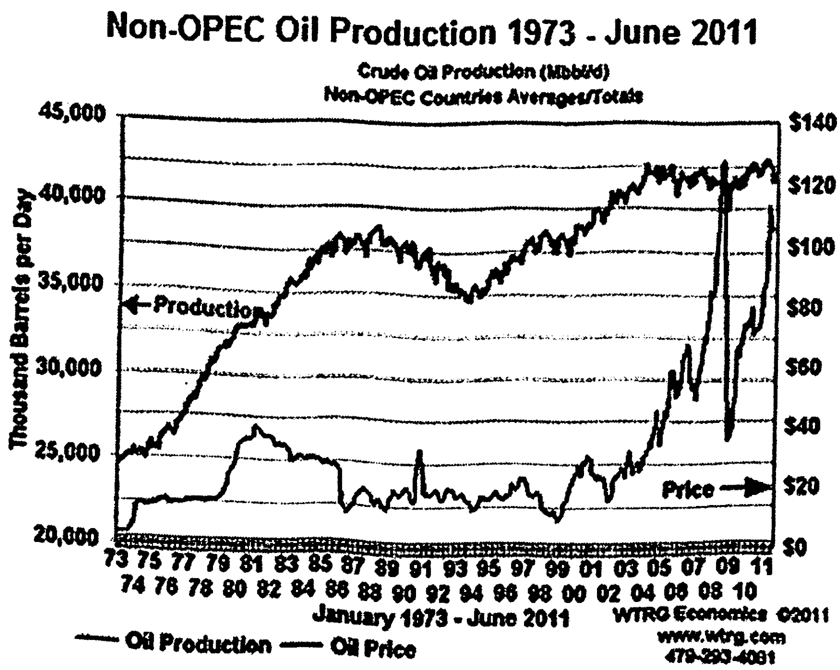
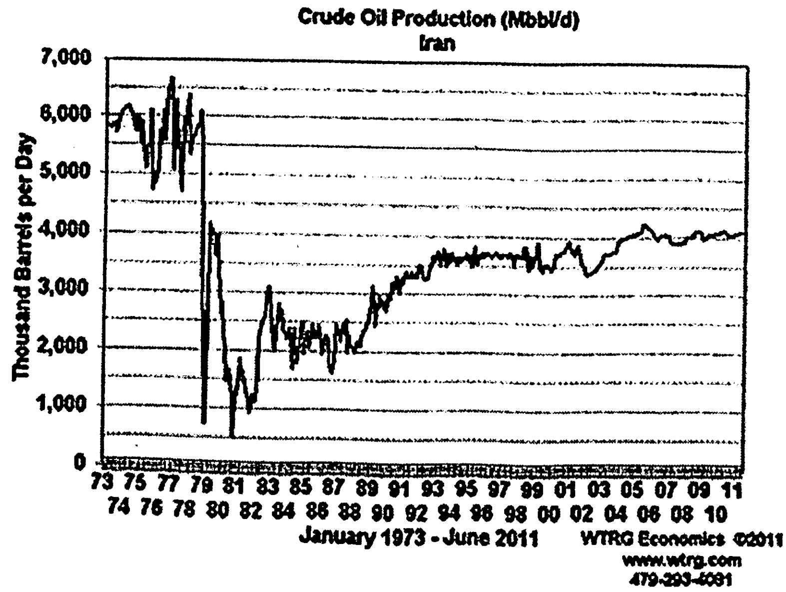


Figure 9: Iran Oil Production 1973-June 2011

Iran Oil production 1973 - June 2011



C) Crises in Iraq-Iran:

In 1979 and 1980, events in Iran and Iraq led to another round of crude oil price increase. The Iranian revolution resulted in the loss of 2.0-2.5 million barrels per day of oil production between November 1978 and June 1979. At one point production almost halted. The Iranian revolution was the proximate cause of the highest price in post-WWII history. However, revolution's impact on prices would have been limited and of relatively short duration had it not been for subsequent events. In fact, shortly after the revolution, Iranian production was up to four million barrels per day.

In September 1980, Iran already weakened by the revolution was invaded by Iraq. By November, the combined production of both countries was only a million barrels per day. It was down 6.5 million barrels per day from a year before. As a consequence, worldwide crude oil production was 10 percent lower than in 1979.

The loss of production from the combined effects of the Iranian revolution and the Iraq-Iran War caused crude oil prices to more than double. The nominal price went from $14 in 1978 to $35 per barrel in 1981. Over three decades later Iran's production is only two-thirds of the level reached under the government of Reza Pahlavi, the former Shah of Iran. Iraq's production is now increasing, but remains a million barrels below its peak before the Iraq-Iran War.

D) U.S. Oil Price Controls:

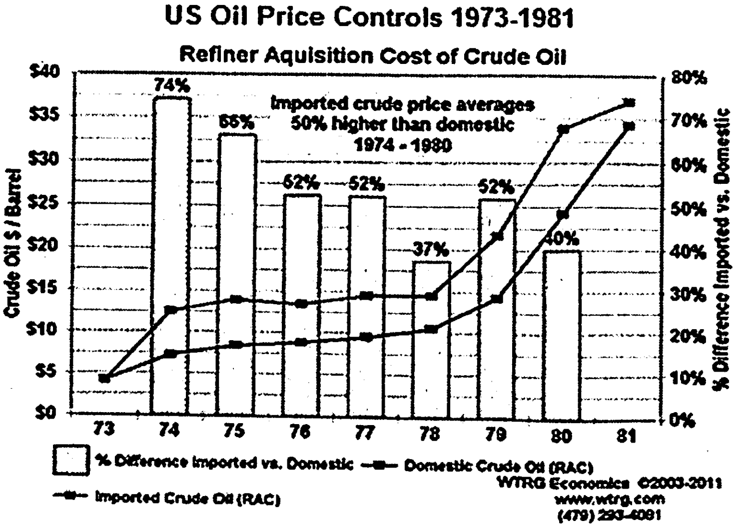
The rapid increase in crude prices from 1973 to 1981 would have been less was it not for United States energy policy during the post Embargo period. The U.S. imposed price controls on domestically produced oil. The obvious result of the price controls was that U.S. consumers of crude oil paid about 50 percent more for imports than domestic production and U.S. producers received less than world market price. In effect, the domestic petroleum industry was subsidizing the U.S. consumer.

In the short-term, the recession induced by the 1973-1974 crude oil price spike was somewhat less severe because U.S. consumers faced lower prices than the rest of the world. However, it had other effects as well.

In the absence of price controls, U.S. exploration and production would certainly have been significantly greater. Higher petroleum prices faced by consumers would have resulted in lower rates of consumption: automobiles would have achieved higher miles per gallon sooner, homes and commercial buildings would have been better insulated and improvements in industrial energy efficiency would have been greater than they were during this period. Fuel substitution away from petroleum to natural gas for electric power generation would have occurred earlier.

Consequently, the United States would have been less dependent on imports in 1979-1980 and the price increase in response to Iranian and Iraqi supply interruptions would have been significantly less.

Figure 10: U.S Oil Price Controls 1973-1981



E) OPEC fails to control crude oil prices:

OPEC has seldom been effective at controlling prices. Often described as a cartel, OPEC does not fully satisfy the definition. One of the primary requirements of a cartel is a mechanism to enforce member quotas.

The Texas Railroad Commission could control prices because the state could enforce cutbacks on producers. The only enforcement mechanism that ever existed in OPEC is Saudi spare capacity and that power resides with a single member not the organization as a whole.

With enough spare capacity to be able to increase production sufficiently to offset the impact of lower prices on its own revenue; Saudi Arabia could enforce discipline by threatening to increase production enough to crash prices. In reality even this was not an OPEC enforcement mechanism unless OPEC's goals coincided with those of Saudi Arabia.

During the 1979-1980 periods of rapidly increasing prices, Saudi Arabia's oil minister Ahmed Yamani repeatedly warned other members of OPEC that high prices would lead to a reduction in demand. His warnings fell on deaf ears. Surging prices caused several reactions among consumers: better insulation in new homes, increased insulation in many older homes, more energy efficiency in industrial processes, and automobiles with higher efficiency. These factors along with a global recession caused a reduction in demand which led to lower crude prices.

Unfortunately for OPEC only the global recession was temporary. Nobody rushed to remove insulation from their homes or to replace energy efficient equipment and factories -- much of the reaction to the oil price increase of the end of the decade was permanent and would never respond to lower prices with increased consumption of oil.

Higher prices in the late 1970s also resulted in increased exploration and production outside of OPEC. From 1980 to 1986 non-OPEC production increased 6 million barrels per day. Despite lower oil prices during that period new discoveries made in the 1970s continued to come online.

OPEC was faced with lower demand and higher supply from outside the organization. From 1982 to 1985, OPEC attempted to set production quotas low enough to stabilize prices. These attempts resulted in repeated failure, as various members of OPEC produced beyond their quotas. During most of this period Saudi Arabia acted as the swing producer cutting its production in an attempt to stem the free fall in prices. In August 1985, the Saudis tired of this role. They linked their oil price to the spot market for crude and by early 1986 increased production from two million barrels per day to five million. Crude oil prices plummeted falling below $10 per barrel by mid-1986. Despite the fall in prices Saudi revenue remained about the same with higher volumes compensating for lower prices.

2. LITERATURE REVIEW

Kumar and **Pandey (2012),** has examined the return and volatility spillover between Indian and international commodity futures markets. For this it is important to understand the market linkages, its origin in the efficient market hypothesis which says that all markets incorporate new information simultaneously and there does not exists any lead-lag relationship across these markets. However, frictions in markets, in terms of transaction costs and information asymmetry, may lead to return and volatility spillovers between markets. Moreover, all the markets do not trade simultaneously for many assets and commodities.

The relationship between the Indian and world commodity futures markets has not been studied in depth and hence, there is a scope for investigating the linkages of Indian commodity futures markets with the counterparts elsewhere in the world trading the futures contracts on the same underlying.

Singh and **Jotwani (2012)** analyzed the relationship between fundamental macroeconomic variables of the economy and stock market is an essential one. It affects the perspective of monetary and fiscal policy decisions, portfolio management and economic development. It has been studied that macroeconomic variables can influence investors' investment decisions. Over the world, many researchers have investigated the relationships between stock market prices and various macroeconomic variables. The focus of the current paper is to investigate whether the share price index can be considered as a reflection of economic activities in India. This study investigates the impact of five selected macroeconomic variables on Stock Market Liquidity of S&P CNX Nifty. As a result of this analysis, a simple model of the influence of macroeconomic fundamentals on the stock market index has been suggested. For better stock market performance, policy makers should put in place measures that will ensure a stable macroeconomic environment.

Jecheche (2005) investigated the Arbitrage Pricing Theory for the case of Zimbabwe using time series data from 1980 to 2005 within a vector autoregressive (VAR) framework. The Granger causality tests are conducted to establish the existence of causality among the variables like inflation, exchange rate and Gross Domestic Product. The VAR estimates as shown by the impulse response and variance decomposition together with the Granger causality test show that there is unidirectional causality from Consumer Price Index to Stock

Prices. Although the Granger causality test has indicated that there is no causality between RGDP and Stock Prices, the variance decomposition has shown that the real GDP explains deviations in the Stock Prices in the long run. Granger causality tests found no meaningful relationships between Stock Prices and Exchange Rate but considering impulse response functions the effect is significant as early as the first period.

Sarver and **Philippatos (1993)** explored the nature of the spot foreign exchange risk premium in their paper "**The Arbitrage Pricing Theory and Foreign Exchange Risk Premia**. Employing Ross's Arbitrage Pricing Theory (APT) as a vehicle, it tests the hypothesis that cross-sectional differences in pure currency returns depend on measures of systematic (covariance) risk. These tests have greater power, in the sense of an enhanced ability to reject the hypothesis, since they explicitly allow for the possibility that idiosyncratic risk is priced. A battery of tests is unable to reject the hypothesis that expected exchange returns can be explained by a single-factor APT. One implication of these results is that official intervention in exchange markets is unnecessary and undesirable.

Korajczyk (1989) evaluated the pricing performance of alternative domestic and international asset pricing models. The models are compared when pricing assets within national economies and, in their international versions, when pricing assets across economies. The pricing models together with the hypothesis of capital market integration imply testable restrictions on multivariate regression models relating asset returns to various benchmark portfolios. Conditional on capital market integration, the tests provide information on the validity of the model. Conversely, given that the assumed type of pricing model is correct, the tests provide information about integration across markets. We compare domestic and international versions of the capital asset pricing model (CAPM) and the arbitrage pricing theory (APT) where the pervasive factors are estimated by an asymptotic principal components technique.

Litzenberger and **Rabinowitz (1995)** develop a model based on the option pricing theory. In their model, oil reserve is viewed as a call option on oil, and therefore its value is greater the greater the oil price volatility (based on the option pricing theory). They view backwardation as the price to pay for the producers to refrain from keeping oil in the ground. Prior to Litzenberger and Rabinowitz (1995) theory, no model had predicted any association between backwardation and volatility. They argue that backwardation of crude oil prices is a necessary condition for crude oil production and greater uncertainty regarding future crude oil prices will lead to stronger backwardation because greater uncertainty means higher value of oil reserve (i.e., greater tendency to keep oil in the ground). Stated differently, Litzenberger and Rabinowitz (1995) model considers the effects of oil price volatility and examines the relation between volatility and the slope of the forward curve. When volatility is high, the value of delaying production increases, causing current prices to increase relative to future prices. Their model implies that, when riskiness increases, oil production is non-increasing and inter-temporal oil price spreads are non-decreasing. In specific, their theory predicts a positive association between backwardation and volatility. Regressing weak backwardation on the implied volatility of the at the- money put option price using the Black (1976) formula, Litzenberger and Rabinowitz (1995) using data on U.S. oil production, U.S. oil reserves, and West Texas Intermediate futures and options prices show that the coefficient on implied volatility is significantly positive over the period from December 1986 through December 1991.

Brennan and **Schwartz (1985)** as well as **Gibson** and **Schwartz (1990)** study the marginal convenience yield; they argue that backwardation should be equal to the present value of the marginal convenience yield of the commodity inventory. The convenience yield is the benefit of owning the physical asset and it measures the market's expectations about the future availability of the commodity. The higher the perceived risk of future shortages in supply, the higher the convenience yields. If the convenience yield is high enough and exceeds the cost of carry, the future market is likely to shift into backwardation. With a low or negative convenience yield, the future market is likely to stay in contango.

Milonas and **Henker (2001)** argue that backwardation could be explained by supply and demand imbalances. They model the Brent crude oil and West Texas Intermediate (WTI) futures spread as a function of the convenience yields of the two contracts. They use convenience yields as surrogates for supply and demand conditions in the two markets and find that convenience yields can explain the variation in the spread. This indicates that the regional supply and demand imbalance is an important factor in determining oil futures prices. In a recent study, Alquist and Kilian (2010) also view supply and demand imbalance as an explanation of oil futures backwardation. They show that the overshooting of the price of oil in response to oil- market specific demand shocks coincides with the predictions of theoretical models of precautionary demand shocks driven by increased uncertainty about future oil supply shortfalls. Using oil futures market data since 1989, Alquist and Kilian (2010) show that the movements in the price of oil induced by this shock are highly correlated (as high as 80%), with independent measures of the precautionary demand component of the real price of oil based on crude oil futures prices.

Larson (1994) developed a stochastic arbitrage equation to explain backwardation in refined copper. Extending on Larson (1994) work, **Considine** and **Larson (2001)** showed that the equilibrium value of oil inventory contains: the conventional Hotelling's theory, the convenience yield from the theory of storage, and an option value related to price uncertainty. Their results suggest that convenience yield and risk premium is important elements of crude oil backwardation. In fact, **Carlson, Khokher**, and **Titman (2007)** developed a model related to Litzenberger and Rabinowitz (1995) model. In their model they relax Litzenberger and Rabinowitz (1995) assumption that producers are not able to extract all of an oil well's reserves at an arbitrary point. Carlson et al. (2007) analysis shows that volatility of price changes can arise as a natural consequence of the production decisions made by value maximizing resource owners and that this volatility is related to the extent of backwardation as well as contango (futures price greater than spot price).

Moebert (2007) find a modest influence of OPEC's capacity utilization on crude oil. His findings imply that the upward trend at the spot market can be explained by an increasing crude oil demand of emerging markets rather than OPEC's market power. In fact, he views OPEC as a passive observer than a price setter. The findings of Moebert (2007) are unlike Kaufmann et al. (2004) who study OPEC behavior between 1984 and 2002 using data on OPEC quota (defined as the quantity of oil to be produced by OPEC members), OPEC overproduction (the quantity of oil produced minus the OPEC quota), and capacity utilization. They show that OPEC can influence real oil prices, while their econometric specification can produce accurate in-sample static and dynamic forecasts.

Horan, Peterson, and **Mahar** (2004) examined the behavior of crude oil implied volatility surrounding OPEC meetings, and their results show that volatility drifts upward as the meeting approaches. Similarly, Wang, Wu, and Yang (2008) show that the realized crude oil futures volatility responds with an increase in the weeks immediately before the OPEC events recommending price increases.

Pippenger and **Phillips** (forthcoming) show how four common pitfalls cause co-integration tests to reject the law of one price when in fact it holds. They conclude that there is no reliable evidence that rejects the LOP. We consider a stronger test, half-life. The literature suggests the half-lives for differentials in spot prices last several quarters. We show that, when we avoid the four common pitfalls, half-lives for differentials for spot grain prices range from 3 to 8 weeks. Such short half-lives have potentially important implications for the Borders literature and real exchange rates.

3. OBJECTIVE

1. To examine the relationship between correlation between domestic futures price and world futures prices.
2. To Study the possible Arbitrage opportunities under different institutional framework.

4. RESEARCH METHODOLOGY

1. Time Series Technique:
    a. Unit Root Test (Augmented Dicky Fuller Test)
    b. Co-Integration Method: Johansen Co-integration Test
2. Error Correlation Model: VECM Model

Data: The required futures price of crude oil in domestic market was collected from MCX which is located in Mumbai, India. MCX is the ninth largest commodity exchange for trading of bullion, currency, metal and energy commodity futures. In the later part of the research we have shown as to how MCX has its importance in the international market and why we have chosen crude oil as the commodity for carrying out the market study. Data of few commodities like Agricultural, Bullion, metal and energy is collected from forward market commission in order to study the share of energy in the total commodities traded over MCX over the period of seven years. The data has been collected from the year 2006 to 2013.

5. TREND ANALYSIS

5.1 Sector Wise Data:

Table 1: Value traded in the exchanges in different sectors globally (2006-2012)

	2006	2007	2008	2009	2010	2011	2012
Agriculture	4,890	640,683,907	894,633,132	927,693,001	1,305,384,722	996,837,283	1,270,531,588
Currency	240,053,180	459,752,816	597,481,714	992,397,372	2,401,872,381	3147046787	2,434,238,493
Energy	385,965,150	496,770,566	580,952,996	657,025,702	723,590,380	814774756	905,856,150
Equity Index	4,454,222,902	5,499,833,555	6,488,621,284	6,382,027,655	7,413,788,422	8462371741	6,048,262,461
Individual Equity	2,876,486,897	4,400,437,854	5,511,194,380	5,588,884,611	6,285,494,200	7062567141	6,467,944,406
Interest Rate	3,193,410,504	3,745,176,350	3,204,838,617	2,467,763,942	3,208,813,688	3491200684	2,933,255,540
Non-Precious Metals	116,383,437	106,859,969	198,715,383	462,823,715	643,645,225	435,113,003	554,253,069
Other	4,360,194	26,140,974	44,896,671	114,475,070	137,655,881	229,713,692	236,778,479
Precious Metals	102,298,908	150,976,113	157,443,026	151,512,950	175,002,550	342,057,656	319,267,659

From the above tabled data we can find out the performance of various sectors in various electronic markets in the world. Looking at the market sentiments, the futures related to agriculture sector have outpaced every other sector from 2006. Agriculture sector on electronic exchanges has grown several 1000 times. This growth of the agriculture sector related futures can be attributed to the vast potential they have due to the delayed introduction in the electronic markets. Whereas market performance of the equity indexes and interest rate index has been inconsistent; growing till 2008 and then due to the global financial crisis these markets saw a setback after which these markets corrected their track of growth. And there is this third kind of sector, for example looking at the energy derivatives trading globally, it has been increasing steadily within this period because the energy demand is inelastic in nature and has a relatively maturing market than any other sector.

Looking at the domestic side of these sectors as shown in table 2, we find that trading in both the sectors, agriculture and the energy, have grown several thousand times implying that India exchanges have been making a significant impact in the global market. Over the period of time, Indian exchanges have emerged as one of the top most exchanges on over which trading takes place in a significant manner.

In 2005-06, the percentage share of energy in the total trading occurring in the various sectors was 0.33% which has grown to 22.1%. This clearly shows the importance of energy sector as compared to other sectors in the domestic market. The growth which has occurred portrays the ever increasing demand of energy in the domestic market which has given rise to huge volumes being traded. The increase in value is more than the volume traded because of the value of money which has fallen over the years.

Figure 11: Value traded in the exchanges in different sectors globally

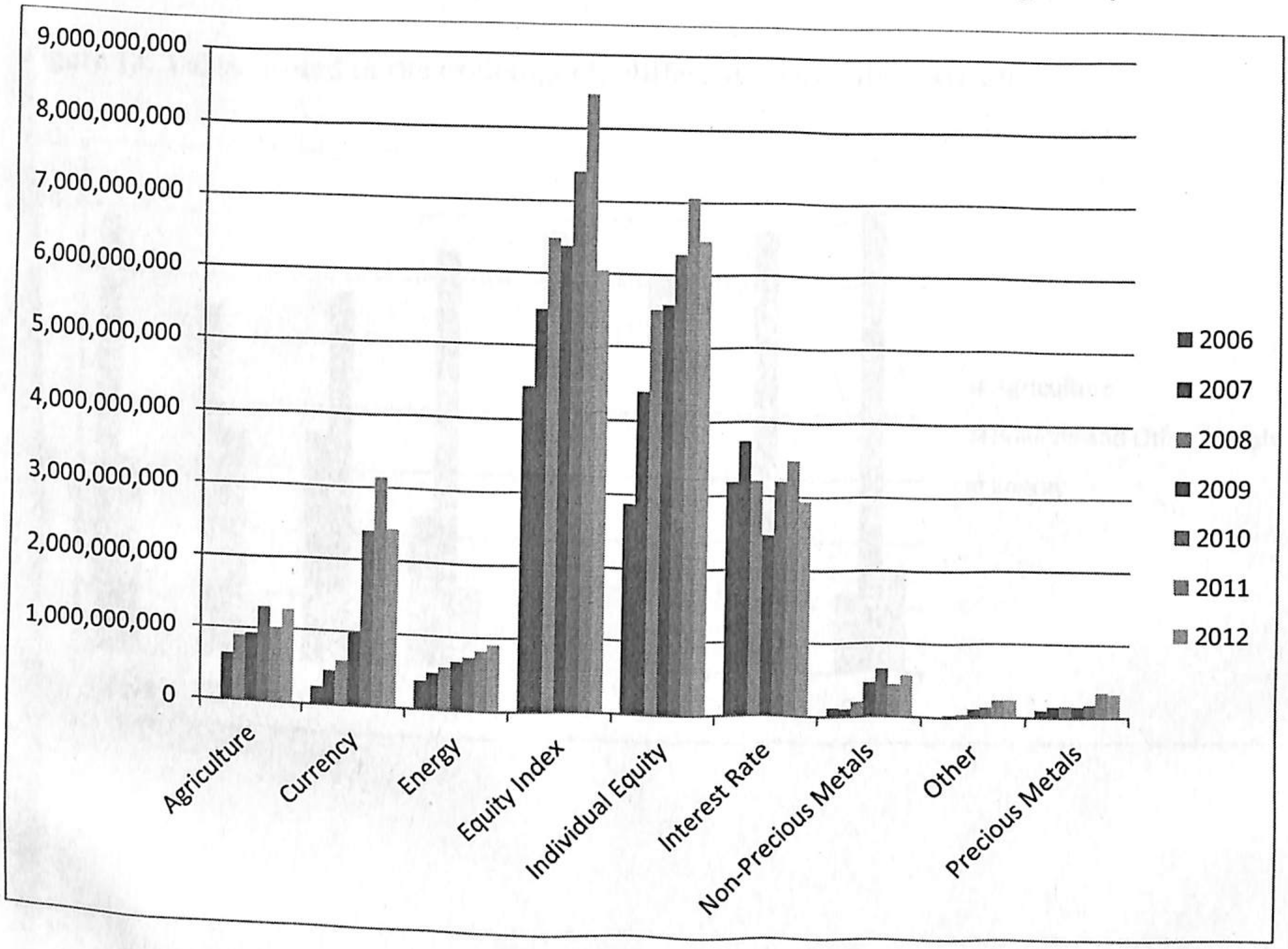


Table 2: Value traded in the exchanges in different sectors domestically

Commodity Group	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13
Agriculture	3901.8	11922.2	13171.2	9412.8	6273	9022	14563.9	21961.5	2155700.4
Bullions & Other Metals	1796.7	7793.9	21289.8	26236.6	35924.50	33883.7	81815.6	130786.7	3260050.7
Energy	19.00	1818.8	2307.1	5009.4	10264.42	12326.1	23109.5	28512.6	3768408.9
Others	0.00	16.14	1.04	0.97	27.61	31.03	0.29	0.08	1.28
Total	5717.6	21551.2	36769.2	40659.8	52489.5	55262.9	119489.4	181261.0	17046840

Figure 12: Value traded in the exchanges in different sectors domestically

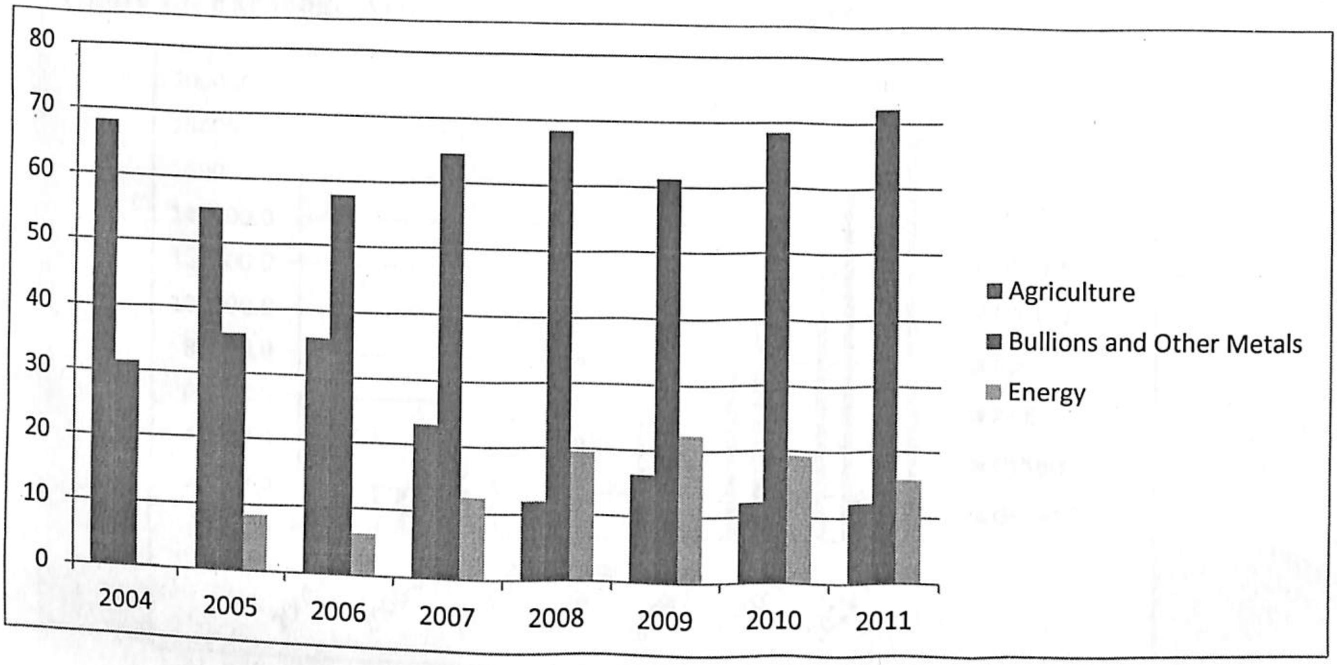
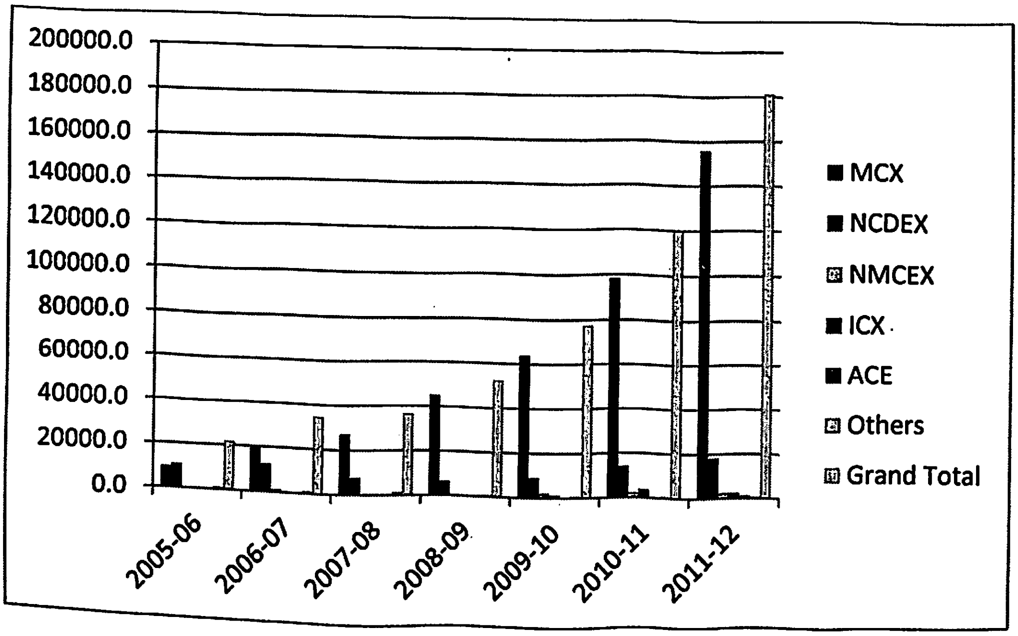


Table 3: Exchange-wise turnover of Indian Exchanges

Exchanges	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
MCX	9616.3	20256.6	27304.2	45124.4	63933.0	98415.0	155971.0
NCDEX	10666.9	12433.3	7749.7	6280.7	9175.8	14106.0	18102.1
NMCEX	183.9	1114.6	250.6	434.5	2279.0	2184.1	2683.5
ICX	0.0	0.0	0.0	0.0	1364.3	3777.3	2581.1
ACE	0.0	0.0	0.0	0.0	0.0	300.6	1386.5
Others	1084.2	1040.3	1240.5	838.9	895.4	706.4	536.9
Grand Total	**21551.2**	**34844.9**	**36544.9**	**52678.5**	**77647.5**	**119489**	**181261**

Figure 13: Exchange-wise turnover of Indian Exchanges



5.2 Exchange-Wise Data:

For the ease of understanding, the exchange wise data has been divided into two categories:

a) Rank of the Top Twenty Exchanges Globally

b) Total Value Traded over the Top Twenty Exchanges Globally

The data has been collected from the year 2005 to 2012, of the top twenty exchanges. This has been done to decide as to over which exchange the maximum trading of commodities occur. Over the period of time of approximately 7 years we find that CME group has been on the top followed by Eurex, whereas other exchanges have been exchanging positions in the various years. If we look at MCX, it has emerged to be one of the top 10 exchanges globally in the past 4 years.

Table 4: Ranks of top 20 global exchanges

Year	2005	2006	2007	2008	2009	2010	2011	2012
CME Group	1	1	1	1	3	2	2	1
Eurex *	2	2	3	2	2	3	3	2
NSE, India	7	8	9	8	7	5	5	3
NYSE Euronext *	4	4	-	4	4	4	4	4
Korea Exchange	13	15	2	3	1	1	1	5
BM&FBovespa	5	6	7	6	6	6	6	6
CBOE Holdings *	-	-	5	5	5	7	8	7
Nasdaq OMX *	16	20	18	7	8	8	7	8
Moscow Exchange	-	-	-	11	9	10	10	9
MCX,India	-	19	28	22	12	9	9	10
Dalian Commodity Exchange	9	9	17	10	11	13	15	11
IntercontinentalExchange **	14	10	16	12	13	14	12	12
Shanghai Futures Exchange	17	16	27	16	10	11	14	13
Zhengzhou Commodity Exchange	19	18	24	13	14	12	11	14
ASX Group	-	-	-	21	23	21	16	15
BSE	32	32	40	-	-	-	-	16
TMX Group *	-	-	-	-	-	-	17	17
Osaka Securities Exchange	24	24	22	15	16	15	18	18
London Metal Exchange	10	12	25	19	19	19	22	19
JSE South Africa	15	11	13	9	15	16	20	20

Table 5: Top 20 global exchanges based upon the value traded annually

Year	2005	2006	2007	2008	2009	2010	2011	2012
CME Group	883.12	1101.71	2805.00	3277.6	2589.55	3080.50	3386.99	2890.04
Eurex *	784.90	960.63	1899.86	3172.7	2647.41	2642.09	2821.50	2291.47
NSE, India	116.29	170.57	379.87	601.6	918.51	1615.79	2200.37	2010.49
NYSE Euronext *	343.83	430.04	0.00	1675.8	1729.97	2154.74	2283.47	1951.38
Korea Exchange	57.88	60.17	2709.14	2865.5	3102.89	3748.86	3927.96	1835.62
BM&FBovespa	187.85	258.47	426.36	741.9	920.38	1413.75	1500.44	1635.96
CBOE Holdings *	0.00	675.21	945.61	1194.5	1135.92	1123.51	1216.92	1134.32
Nasdaq OMX *	34.14	45.04	142.51	722.1	814.64	1099.44	1295.64	1115.53
Moscow Exchange	0.00	0.00	0.00	238.2	474.44	623.99	1082.56	1061.84
MCX,India	20.49	45.63	68.95	103.0	384.73	1081.81	1196.32	959.61
Dalian Commodity Exchange	99.17	117.68	185.61	319.2	416.78	403.17	289.05	633.04
IntercontinentalExchange **	41.94	92.58	195.71	234.4	257.12	328.95	381.10	473.90
Shanghai Futures Exchange	33.79	58.11	85.56	140.3	434.86	621.90	308.24	365.33
Zhengzhou Commodity Exchange	28.47	46.30	93.05	222.6	227.11	495.90	406.39	347.09
ASX Group	0.00	0.00	0.00	94.8	82.20	106.39	225.35	259.97
BSE	8.91	13.66	18.83	0.0	0.00	0.00	0.00	243.76
TMX Group *	0.00	0.00	0.00	0.0	0.00	136.05	201.66	209.35
Osaka Securities Exchange	18.07	31.17	108.92	163.7	166.09	196.35	194.18	205.13
London Metal Exchange	70.44	78.53	92.91	113.2	111.93	120.26	146.60	159.72
JSE South Africa	36.46	87.04	329.64	513.6	166.59	169.90	166.20	159.00
Malaysia Derivatives Exchange	2.46	4.16	6.20	0.0	0.00	0.00	0.00	9.60

Figure 14: Value Traded over the Top 20 Global Exchanges

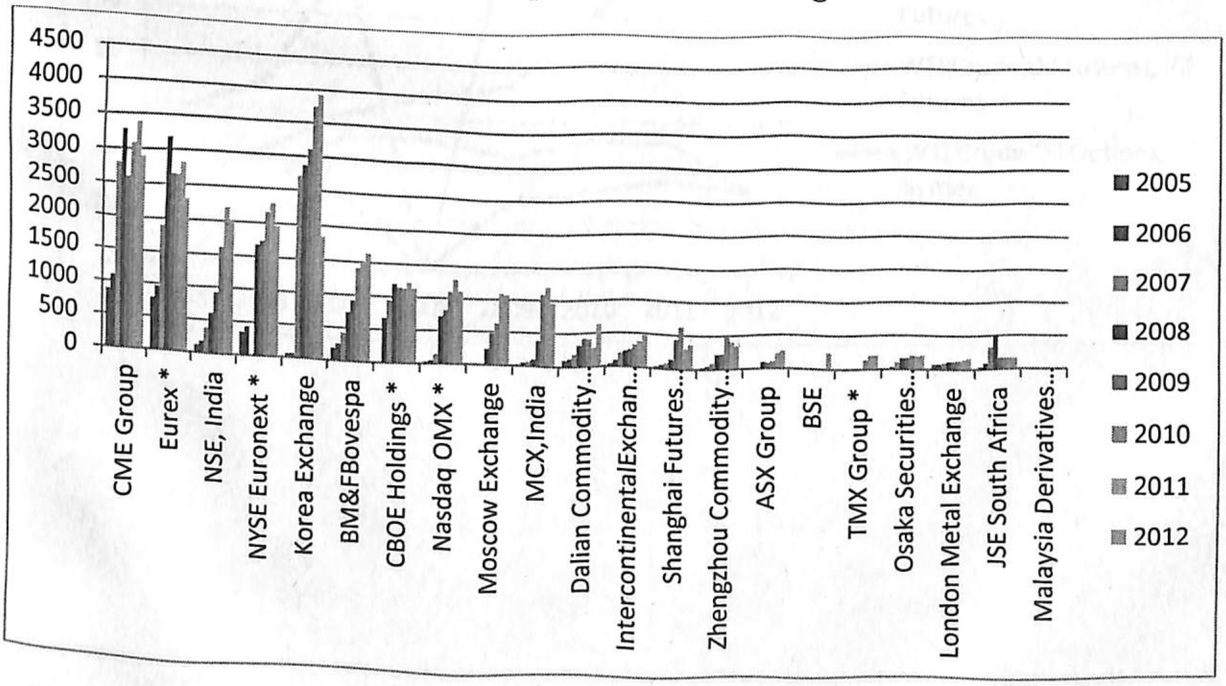


Table 6 presents the energy commodities amongst the top 20 commodities being traded worldwide. The purpose of choosing these contracts is just to show the importance of crude oil in the commodity market worldwide. NYMEX futures and ICE futures have been among the most traded commodity contracts and hence, we chose to take NYMEX as the international exchange. Moreover, NYMEX is the exchange under CME group, over which energy commodities are traded. We already saw that CME group has been amongst the top exchanges for commodity trading and NYMEX comes under CME for the trading of energy commodities.

Table 6: Energy Contracts amongst the top Commodity Contracts

Commodity Contracts/ Year	2005	2006	2007	2008	2009	2010	2011	2012
WTI Crude Oil Futures, Nymex	59.65	71.05	121.52	0	137.42	168.65	175.03	140.53
Brent Crude Oil Futures, ICE Futures	30.41	44.35	59.72	68.36	74.13	100.02	132.045	147.38
WTI Crude Oil Futures, ICE Futures	0	28.67	51.38	51.09	46.39	52.58	51.097	33.14
WTI Crude Oil Options, Nymex	14.73	21.02	28.39	0	28.55	32.78	36.71	32.52

Figure 15: Energy Contracts traded globally

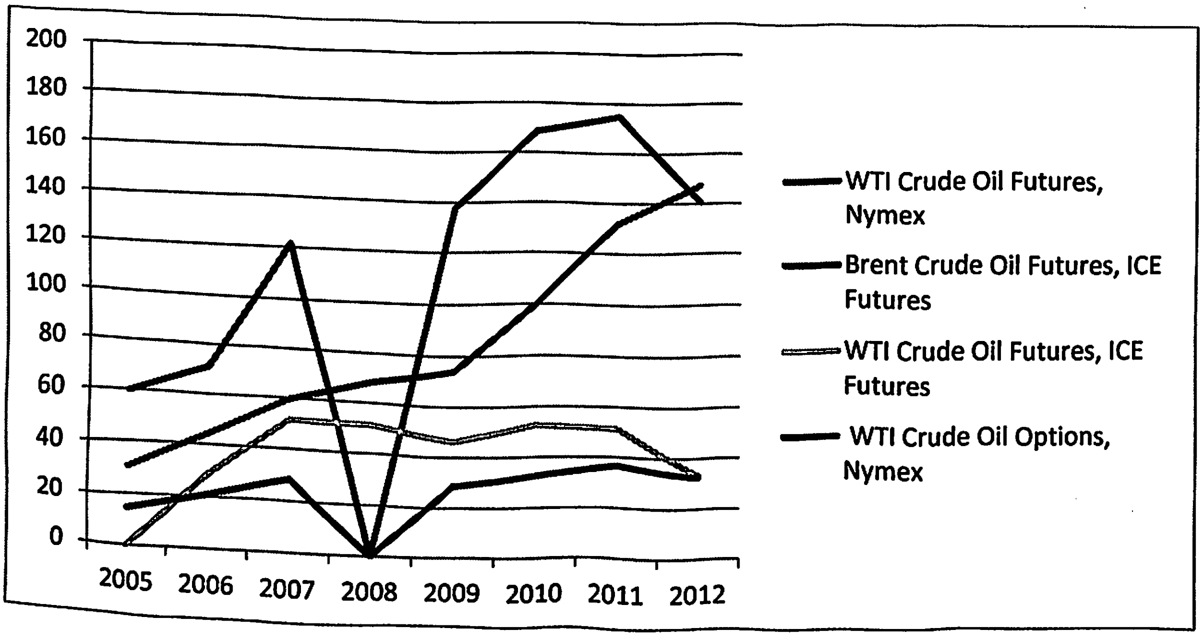
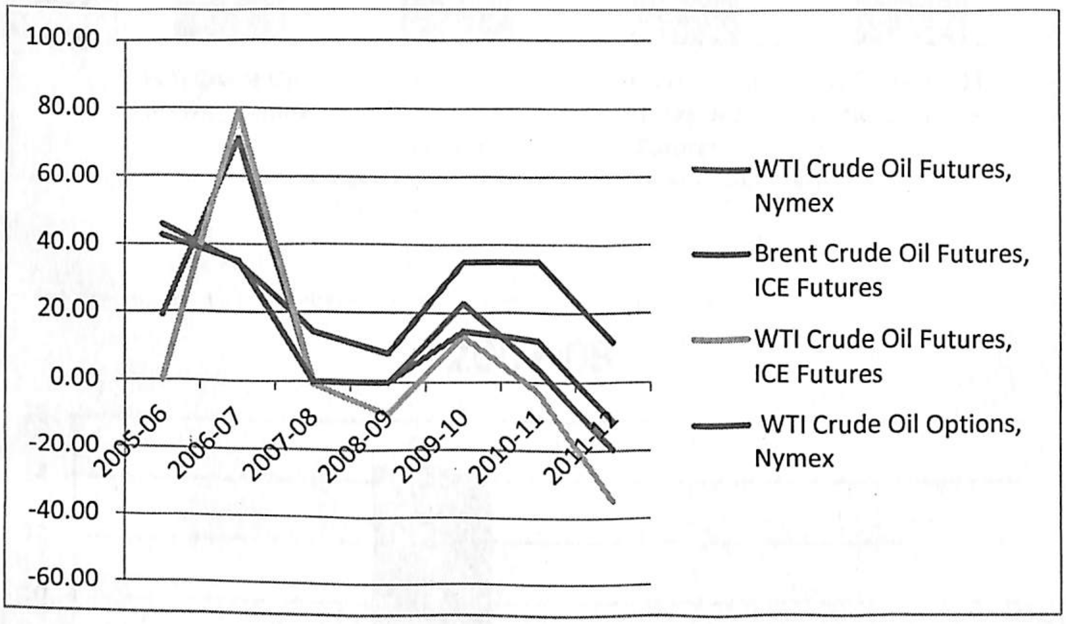
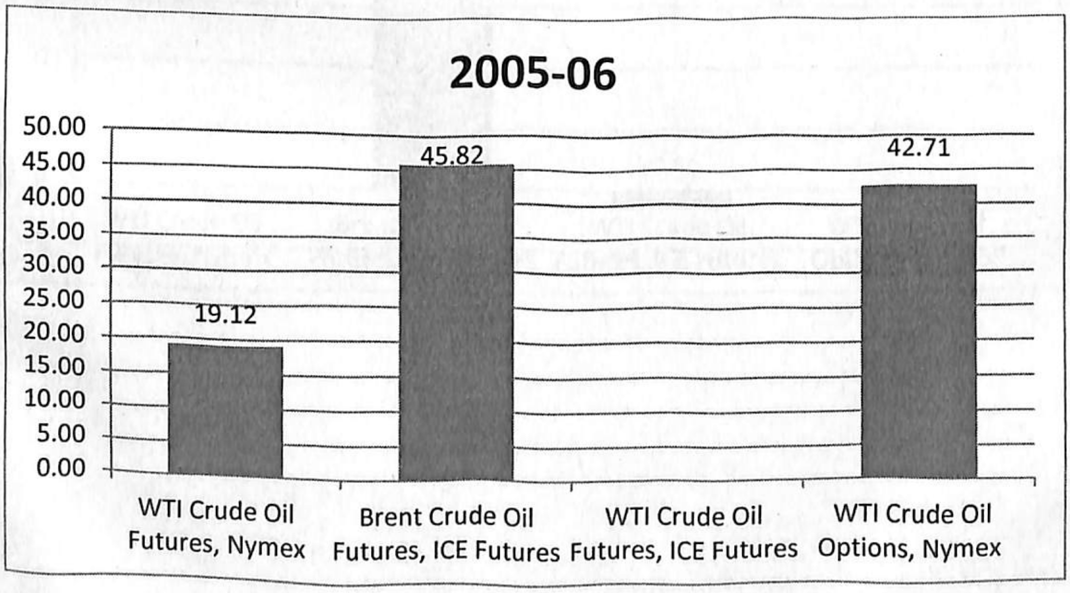


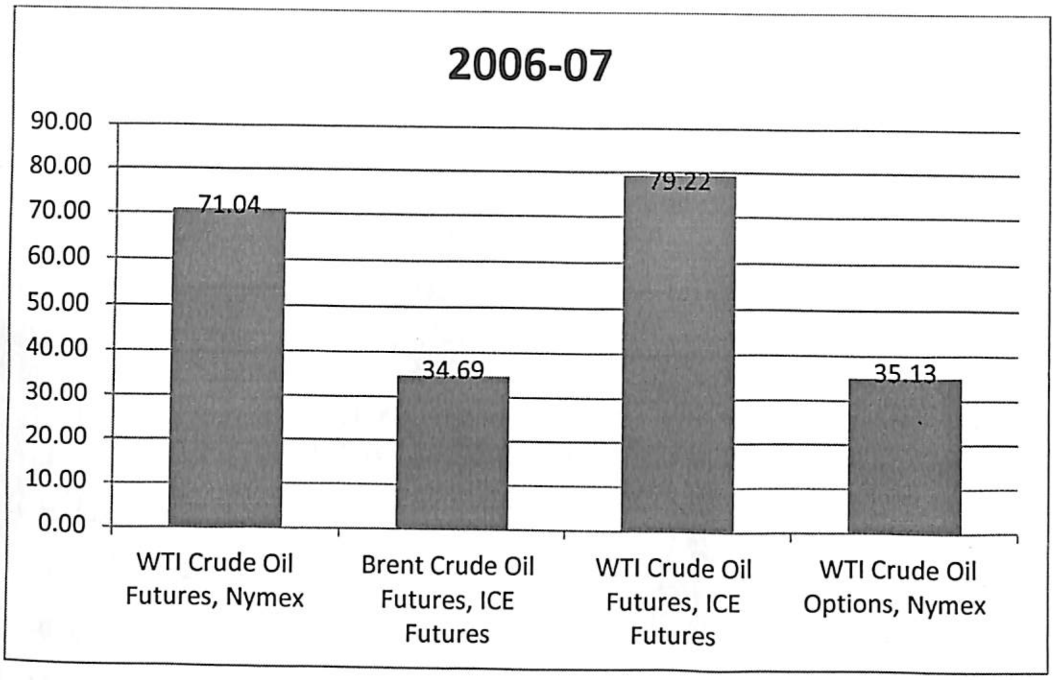
Table 7: Volatility of the energy contracts over the years

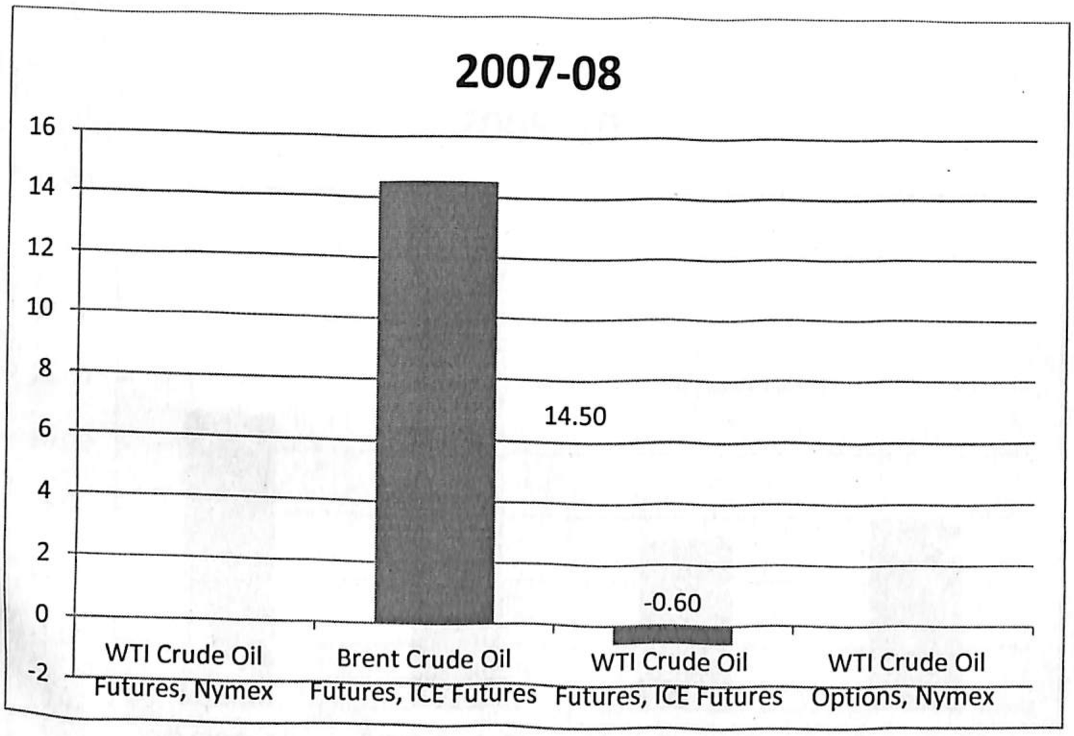
	Volatility						
Commodity Contracts	**2005-06**	**2006-07**	**2007-08**	**2008-09**	**2009-10**	**2010-11**	**2011-12**
WTI Crude Oil Futures, Nymex	19.12%	71.04%	0	0	22.70%	3.78%	-19.70%
Brent Crude Oil Futures, ICE Futures	45.82%	34.69%	14.50%	8.40%	34.90%	34.93%	11.60%
WTI Crude Oil Futures, ICE Futures	0	79.22%	-0.60%	-9.19%	13.30%	-2.90%	-35.10%
WTI Crude Oil Options, Nymex	42.71%	35.13%	0	0	14.80%	11.98%	-11.40%

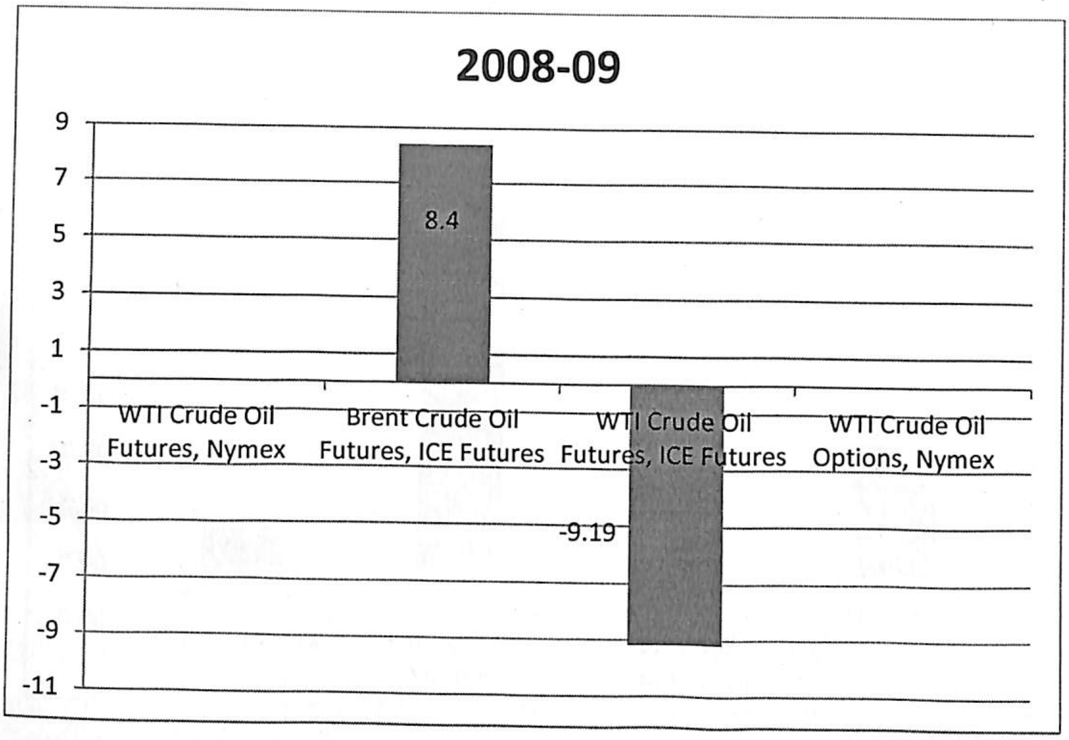
Figure 16: Volatility of the Energy Contracts

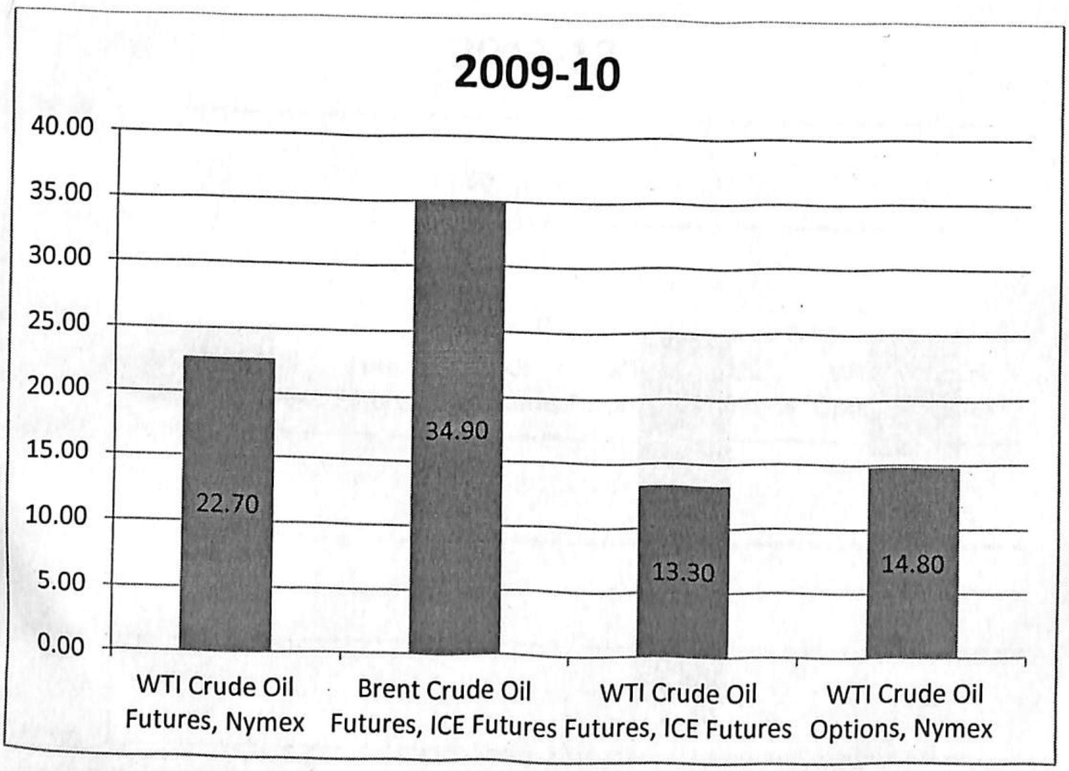


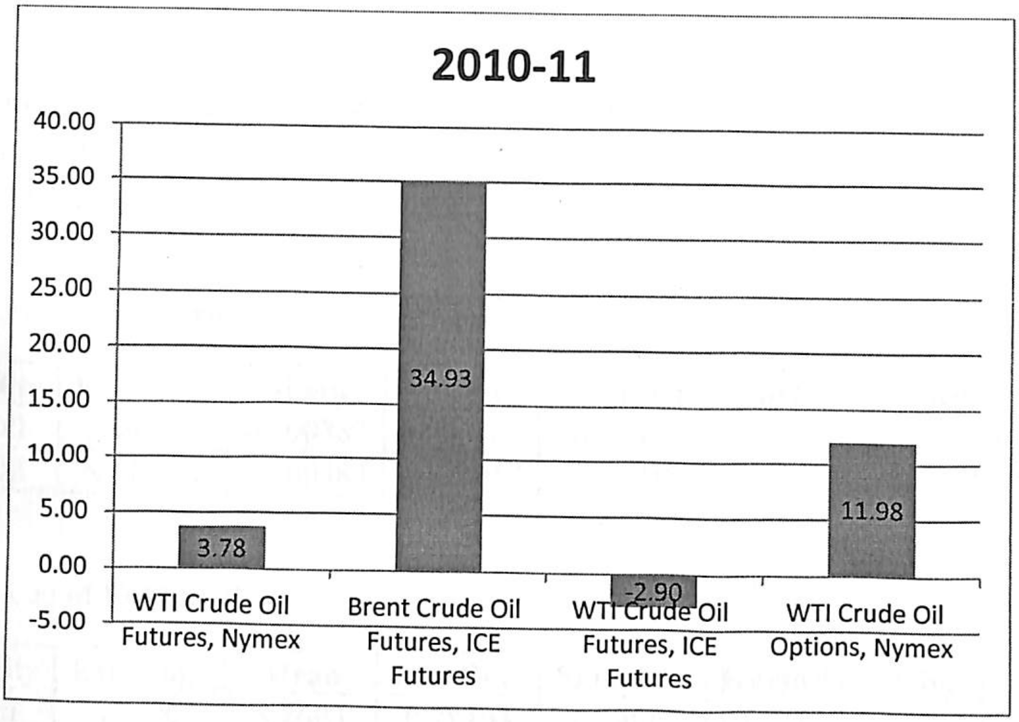



2006-07
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
71.04
34.69
79.22
35.13
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex


2007-08
16
14
12
10
8
6
4
2
0
-2
14.50
-0.60
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex


2008-09
9
7
5
3
1
-1
-3
-5
-7
-9
-11
8.4
-9.19
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex


2009-10
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
22.70
34.90
13.30
14.80
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex


2010-11
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
3.78
34.93
-2.90
11.98
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex

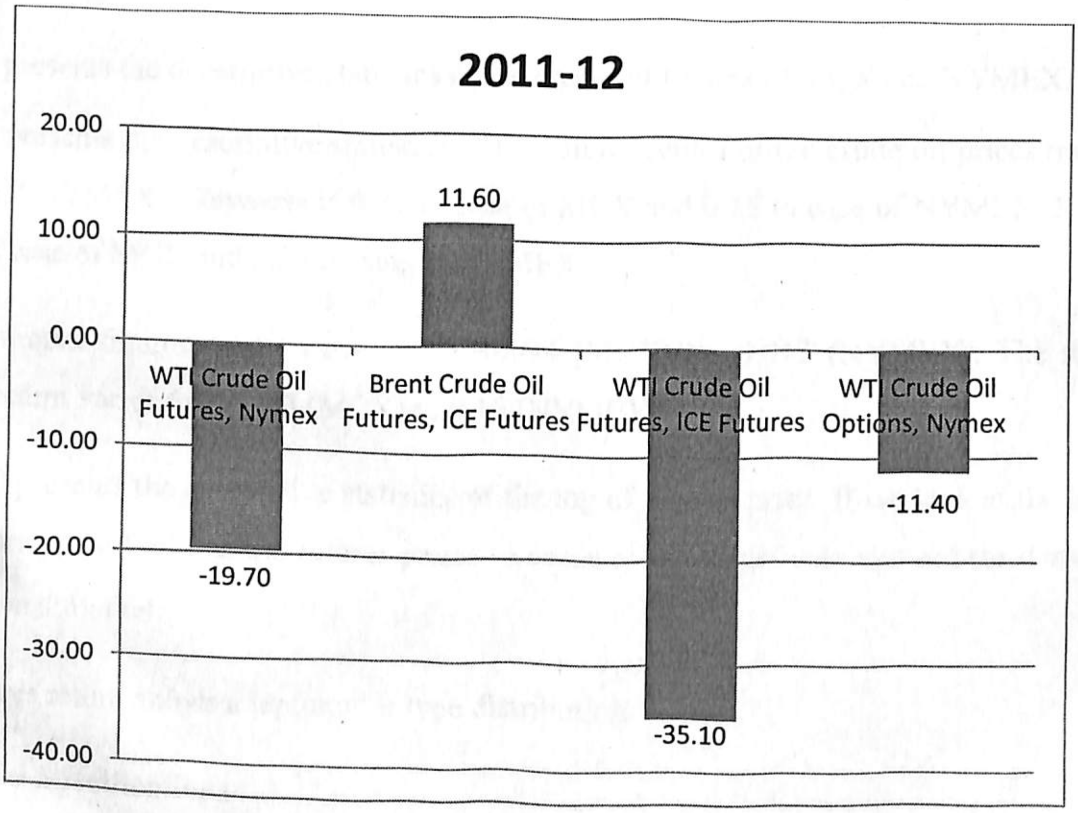

2011-12
20.00
10.00
0.00
-10.00
-20.00
-30.00
-40.00
-19.70
11.60
-35.10
-11.40
WTI Crude Oil Futures, Nymex
Brent Crude Oil Futures, ICE Futures
WTI Crude Oil Futures, ICE Futures
WTI Crude Oil Options, Nymex

Table 8: Futures Price

Commodity	Exchange	Mean	Std.Dev.	Skewness	Kurtosis	Min.	Max.
Crude oil	MCX	4023.6	1124.9	0.3995	-0.56351	1641	7507
Crude oil	NYMEX	3957	1043.4	0.16748	-0.54348	1463.5	6524.4

Table 9: Futures Return

Commodity	Exchange	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Crude Oil	MCX	0.000387	0.020565	0.77352	11.447	-0.094389	0.23898
Crude Oil	NYMEX	0.000384	0.024915	0.15249	5.2337	-0.13229	0.16201

Table 10: Log of Futures Price

Commodity	Exchange	Mean	Std. Dev.	Skewness	Kurtosis	Min.	Max.
Crude oil	MCX	8.2603	0.28404	-0.14062	-0.62365	7.4031	8.9236
Crude oil	NYMEX	8.2461	0.27922	-0.53334	0.27536	7.2886	8.7833

Table 8 presents the descriptive statistics of the crude oil futures of MCX and NYMEX.

Table 9 presents the descriptive statistics of the futures return of the crude oil prices traded over MCX and NYMEX. Skewness is 0.77 in case of MCX and 0.15 in case of NYMEX. Kurtosis is 11.45 in case of MCX and 5.23 in case of NYMEX.

The minimum futures return varies from -0.094 (MCX) to -0.013 (NYMEX). The maximum futures return varies from 0.23 (MCX) to 0.16 (NYMEX).

Table 10 presents the descriptive statistics of the log of futures price. If we look at the log of the futures price, we find that the futures prices of crude oil are negatively skewed for domestic and international market.

The futures return shows a leptokurtic type distribution.

5.3 Model Specifications

The theoretical relationship between domestic and international futures market is based on the cost-of-carry model and efficient market hypothesis. Having established S_t and F_t series are I

(1), Johansen-Juselius (J-J, 1990) multivariate cointegration test and vector error correction model (VECM) can be used to examine the long-run and short-run deviations from equilibrium.

$$S_t - \beta_0 - \beta_1 F_t = \varepsilon_{s,t} \quad (2)$$

$$F_t - \alpha_0 - \alpha_1 S_t = \varepsilon_{f,t} \quad (3)$$

Where S_t and F_t are contemporaneous spot and futures prices at time t; α and β are parameters; and ε_t is deviation from parity. J-J test is based on the following vector autoregressive (VAR) representation:

$$Y_t = A_0 + A_1 Y_{t-1} + A_1 Y_{t-2} + ... + A_k Y_{t-k} + \varepsilon_t \quad (4)$$

Where $Y_t = [S_t \;\; F_t]'$ is a (2×1) column vector of non-stationary log-spot(S_t) and log-futures prices (F_t); $\varepsilon_t = [\varepsilon_{s,t} \;\; \varepsilon_{f,t}]'$ is a (2×1) column vector of white noise error, A_0 is a (2×1) column vector of constants; A is a (2×2) matrix of coefficients. The Equation 4 can be transformed into following:

$$\Delta Y_t = A_0 + \Pi Y_{t-k} + \Gamma_1 \Delta Y_{t-1} + ...+ \Gamma_{k-1} \Delta Y_{t-k+1} + \varepsilon_t \quad (5)$$

$$\Delta Y_t = A_0 + \Pi Y_{t-k} + \sum_{i=1}^{k-1} \Gamma_i \Delta Y_{t-i} + \varepsilon_t \quad (6)$$

Where, $\Pi = \sum_{j=1}^{k} A_i - I$ and $\Gamma_i = \sum_{j=1}^{i} A_j - I$

The existence of cointegrating relations can be examined through Π matrix. The Π matrix can be written as $\Pi = \alpha\beta'$; β represents the matrix of cointegrating parameters, and α is the matrix of the speed of adjustment parameters. To identify the number of cointegrating vectors and their estimates, J-J cointegration test uses two likelihood ratio statistics: trace and maximum eigenvalue.

Trace statistic: $\lambda_{Trace}(r) = -T \sum_{i=r+1}^{n} \ln(1 - \hat{\lambda}_i)$ (7)

Maximum eigenvalue statistic: $\lambda_{Max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$ (8)

Here T is the number of observations and $\hat{\lambda}_i$ is the estimated value for the ith ordered eigenvalue obtained from the Π matrix. The trace statistic tests the null hypothesis that the number of distinct cointegrating vectors is less than or equal to r against the alternative hypothesis of more than r cointegrating relationships. The maximum eigenvalue tests the null hypothesis that the number of cointegrating vectors is less than or equal to r against the alternative of $r+1$ cointegrating vectors.

According to Granger representation theorem (Engle and Granger, 1987), if sets of series are cointegrated, then there exists a VECM.

$$\Delta S_t = \alpha_1 + \alpha_s ect_{t-1} + \sum_{i=1}^{k} \alpha_{11}(i)\Delta S_{t-i} + \sum_{i=1}^{k} \alpha_{12}(i)\Delta F_{t-i} + \varepsilon_{s,t} \qquad (9)$$

$$\Delta F_t = \alpha_2 + \alpha_f ect_{t-1} + \sum_{i=1}^{k} \alpha_{21}(i)\Delta S_{t-i} + \sum_{i=1}^{k} \alpha_{22}(i)\Delta F_{t-i} + \varepsilon_{f,t} \qquad (10)$$

α_s and α_f are the co-efficients of the error-correction term (ect_{t-1}) which can be interpreted as speed of short-term adjustment factors. It measures how quickly each market reacts to the deviation from the long run equilibrium.

The following bi-variate auto-regression is used to examine the Granger causality test between spot and futures returns.

$$\Delta S_t = \alpha_1 + \sum_{i=1}^{k} \alpha_{11}(i)\Delta S_{t-i} + \sum_{i=1}^{k} \alpha_{12}(i)\Delta F_{t-i} + \varepsilon_{s,t} \qquad (11)$$

$$\Delta F_t = \alpha_2 + \sum_{i=1}^{k} \alpha_{21}(i)\Delta S_{t-i} + \sum_{i=1}^{k} \alpha_{22}(i)\Delta F_{t-i} + \varepsilon_{f,t} \qquad (12)$$

The null hypothesis that futures returns does not Granger cause spot returns will be rejected if the coefficients $\alpha_{12}(i)$ in Equation (11) are found to be jointly statistically significant, based on F-test. Similarly, the null hypothesis that spot Granger causes futures will be rejected if the coefficients, $\alpha_{21}(i)$ in Equation (12) are jointly significant. Bi-directional causality is suggested if both $\alpha_{12}(i)$ and $\alpha_{21}(i)$ coefficients will jointly be statistically significant.

5.4 Stationarity Test

Augmented Dicky Fuller (ADF) Test results are presented in Table **11.** This test shows that the log future price for level is non-stationary for both the exchanges' crude oil. The null hypothesis of non-stationary is statistically not significant at 1% level of significance as denoted by the test critical values. The result of the unit root test or the Augmented Dicky fuller test or the stationarity test indicates that we can proceed for the cointegration analysis, where the result of the first condition i.e. both the series have to be non-stationary in level and integrated of order one for the Johansen-Jusleius test is satisfied. Before testing the cointegration test, vector autoregressive framework, Granger causality test is conducted to know, if any unidirectional or bidirectional causality relationship exists between the futures prices of crude oil in the domestic market and the international market.

Table 11: Unit Root Test

Level (log)	
Constraint	**(MCX)**
I&T	-2.392361
I	-1.388852
None	0.789342

Level (log)	
Constraint	**(NYMEX)**
I&T	-2.731529
I	-1.777119
None	0.626206

First Difference (Log)	
Constraint	**(MCX)**
I&T	-20.07988
I	-44.67199
None	-44.66714

First Difference (Log)	
Constraint	**(NYMEX)**
I&T	-46.50288
I	-46.51282
None	-46.51304

[1]The Fuller critical values for ADF test at 1%, 5% and 10% are -3.43, -2.86 and -2.57 respectively for constant (denoted by I).

[2]The Fuller critical values for ADF test at 1%. 5% and 10% are -3.96, -3.41 and -3.12 respectively for constant + time trend (denoted by I and T).

[3]The Fuller critical values for ADF test at 1%, 5% and 10% are -2.58, -1.95 and -1.62 respectively for no constant or time trend (denoted by None).

Note: The constant "I" stands for Intercept, whereas I&T stand for Intercept and Trend.

The test shows that the log of domestic and international market for level is non stationary. The null hypothesis of non-stationary is statistically not significant for both the price series in level.

5.4.1 Dickey-Fuller Stationarity Test

As was expected, the original series shown above (before we take returns) were not stationary with respect to the Dickey Fuller unit root test at a 1%, 5% or 10% probability level and not cointegrated, neither with an ADF test, nor with a Johansen test.

We observed the autocorrelations in all return series (one, five, ten and one hour) and we attempted to build ARMA models for the univariate cases.

In the Dickey-Fuller and the Augmented Dickey-Fuller test, the observed τ statistic, the t statistics for δ (the coefficient for the lagged variable in the level in the test equation), is compared with the critical value provided by Mc Kinnon (1991), who has provided response surface estimated (optimal design) of the crucial values of the Dickey-Fuller statistics. The Monte Carlo tables given by Dickey (1976) were adjusted slightly by Dickey and Fuller. If τ in absolute values is smaller than the critical values, then the series will not be stationary even after the trend has been removed. In this case, it will be necessary to work with first differences. If the first differences are stationary, the series is I(1), meaning integrated of order 1. The differenced series is then I(0).

The trend stationary process can be written:

$$y_t = \beta_1 + \beta_2 t + u_t ,$$

Where u_t is stationary with, for instance, a constant sample mean $\bar{u}$ equal to zero and a constant variance σ^2.

In the difference stationary process (the random walk if α=0 or the random walk with rift

if $\alpha \neq 0$, we have,

$$y_t - y_{t-1} = \alpha + u_t$$

Where α is a constant.

5.5 Granger Causality Test

Granger causality test is estimated below. The test helps in understanding the relationship among the futures price between domestic and international market before testing for cointegration. The estimation results from the Granger causality test is presented in the Table 12. the null hypothesis of future return of domestic market, MCX does not granger cause future return of the international market, NYMEX i.e. ($\Delta Frt(d) \neq> \Delta Frt(I)$ is rejected for the crude oil in both the markets.

Similarly, the futures return for international market does not Granger cause the futures return of the domestic market. Thus, the null hypothesis is rejected for both the markets for crude oil. Therefore, futures return of international market cause future return for the domestic market for the commodity crude oil.

Granger causality test suggests a bidirectional causality relationship between futures return of the international market and the domestic market for the price of crude oil.

However, the domestic market here is affecting the international market as per the results but there are several other factors involved which are showing this result such as spot prices, which play a major role in both the markets and which affect the futures price.

Table 12: Granger Causality Test

Commodity	Exchanges	F-Stat	P-Value
Crude Oil	MCX	35.449	7.00E-16
Crude Oil	NYMEX	0.4719	0.6239

Note:
[1]ΔFrt(d), ΔFrt(I)refers to futures return of domestic and international market respectively.
[2]P-value(0.001) refers to the significance at 1% level

5.6 Johansen and Jusleius Cointegration Analysis

Table 13: J-J Test

	H0: rank = 0 Vs H1: rank = 1	H0: rank = 0 Vs H1: rank = 1
Exchange	Max. Trace Value	Max. Eigen Value
None	20.98055	18.15261
At most 1	2.827931	2.827931

Note: [1]Critical values of $\lambda_{Trace}(r)$=0 for 1%, 5% and 10% significance level are 24.6, 19.96 and 17.85 respectively.
[2]Critical Values of $\lambda_{Trace}(r)$=1 for 1%, 5% and 10% significance level are 12.97%, 9.24% and 7.52% respectively.
[3]Critical Values of λ max(r)=0 for 1%, 5% and 10% significance level are 20.2%, 15.67% and 13.752% respectively.
[4]Critical Values of λ max(r)=1 for 1%, 5% and 10% significance level are 12.97%, 9.24% and 7.52% respectively.
[5]AIC lag selection criteria is used for the estimation.

Following the stationarity test results from the previous section, J-J cointegration test is estimated for the futures price of the domestic and international market, which are integrated of order one. $\lambda trace$ test statistic rejects null hypothesis at 5% level for crude oil. Hence, it accepts the null hypothesis of more than zero cointegrating vectors. Both the tests suggest presence of one cointegrating vector of crude oil. Hence, a dynamic VECM is estimated for crude oil, where there is a presence of cointegrating relationship between the domestic and international market.

5.7 Vector Error Correction Model

Table 14: VECM

Coefficient	MCX	NYMEX
α_f	1	-1.4214
	(0)	(-1.854)

Note: [1]Values in the parentheses are t-statistics
[2]Statistical coefficients is considered for at 5% level of significance
[3] α_f represents the coefficient of error correction for futures price

Table 14 presents the results of the analysis of VECM on the futures return. We will look at the domestic market and international market one by one. The coefficient of the error correction term α_f is negative in case of the international market (NYMEX) and positive in case of MCX, which implies that it is statistically significant and the international futures price has a positive impact on the domestic futures price, whereas the domestic market does not affect the futures price of the international market. It also shows that the short-run deviations of the future price would be adjusted in the upward direction towards the long-run equilibrium.

6 CONCLUSIONS

From the various analytical tools, we conclude the following points:

1. Both the Indian and International futures market influence each other, but NYMEX has a stronger impact on Indian prices.

2. Existence of cointegrating relationship implies that both domestic and International futures market have a short-run disequilibrium, which can be corrected by arbitrage process.

3. Unidirectional Volatility spillover from NYMEX to MCX is found.

4. Granger causality test suggests a bidirectional causality relationship between futures return of the international market and the domestic market for the price of crude oil and VECM model indicate that there exists a one-way causality from world markets to Indian market.

5. Efficient market hypothesis says that all markets incorporate any new information simultaneously and there is no lead-lag relationship existing in these markets.

On the contrary, it can be argued that, given the size of the Indian economy, Indian market may also influence world market. This issue has interesting implications in gaining insight on the directionality of information flow and assimilation of the same. The long run relationship between Indian futures price and its world counterparts indicate that the Indian futures market is cointegrated with the world markets.

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