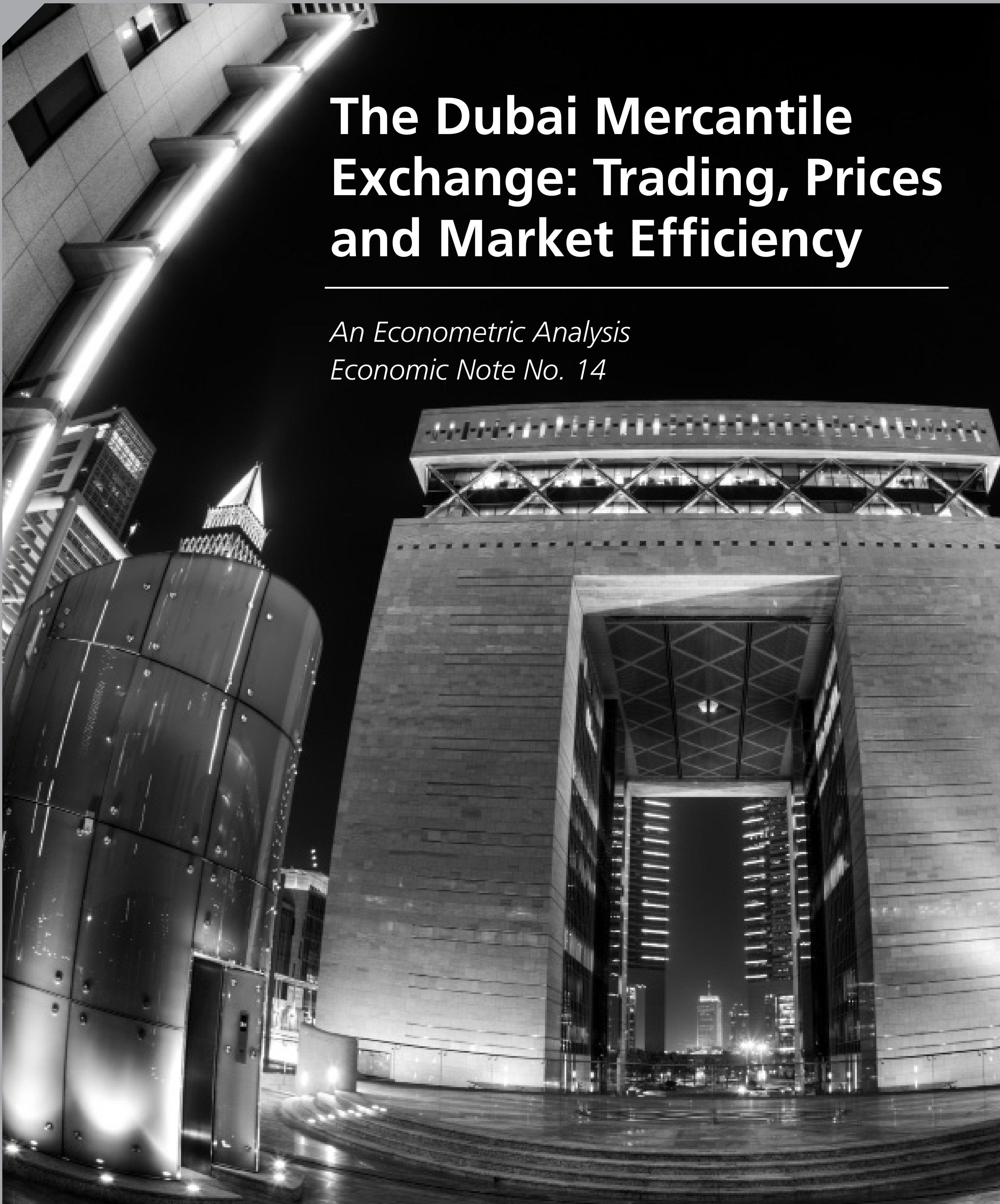
The Dubai Mercantile Exchange: Trading, Prices and Market Efficiency

An Econometric Analysis
Economic Note No. 14



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Abstract

The Dubai Mercantile Exchange Limited (DME) is the energy commodities exchange located in the DIFC that lists and trades the Oman Crude Oil Futures Contracts (DME Oman). The DME Oman is the sole benchmark for Oman and Dubai crude oil official selling prices, and the only market listing sour crude in the region. To date, over two million contracts or two billion barrels of crude oil have been traded over the DME since its launch in June 2007. Furthermore, the average daily volumes in DME touched 3,000 contracts during Q1 2011 with the highest record reached in January 2011 when the average daily volume was 3,570 contracts (equivalent to 3.5 million barrels of oil per day). Today, it is considered the largest physically-delivered crude oil futures contract in the world with a 35% (at an annual rate) rise in trading volume in 1Q2011.

Against this backdrop it is important to test the market efficiency of DME and also test whether the prices are reliable and not subject to manipulation. This paper analyzes the efficiency of DME oil market by using the "weak form of market efficiency", which posits that future prices are optimal predictors of spot prices. Furthermore, the analysis is done using the Hansen and Hodrick correction which allows treating the overlapping observation problem. Our empirical results are consistent with the hypothesis that the DME market is efficient with reliable prices that reflect available market information. The DME has added value to oil markets by providing a transparent market price mechanism at a time of higher than average volatility in oil prices and market conditions.

Keywords

Dubai Mercantile Exchange; Oil Prices; Oman; Dubai; DIFC; Hansen and Hodrick test; Market efficiency

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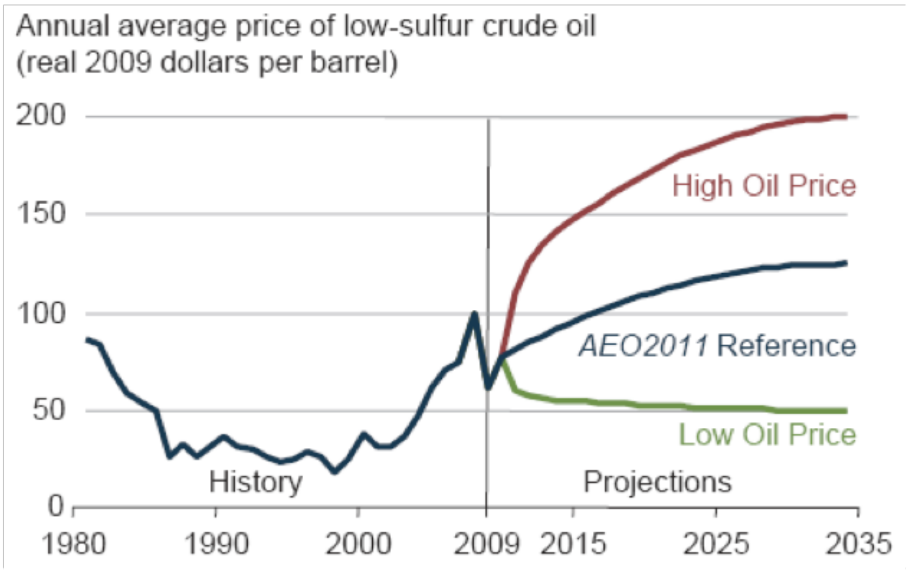
Introduction

The world has experienced several phases of volatile oil prices over time, but the recent phase where it touched $147 a barrel (July 2008) has been the highest (in nominal terms) historically. Economists and energy analysts expect an upward trend for oil prices. The Energy Information Agency's Annual Energy Outlook 2011 projects that crude oil prices will continue to rise gradually, as the world economy recovers and global demand is expected to grow more rapidly than incremental non-OPEC supply. In 2035, the average real price of crude oil in the "Reference" case[1] is placed at $125 per barrel in 2009 dollars, or about $200 per barrel in nominal dollars (Figure below).

Figure No. 1: World crude oil prices, 1980-2035



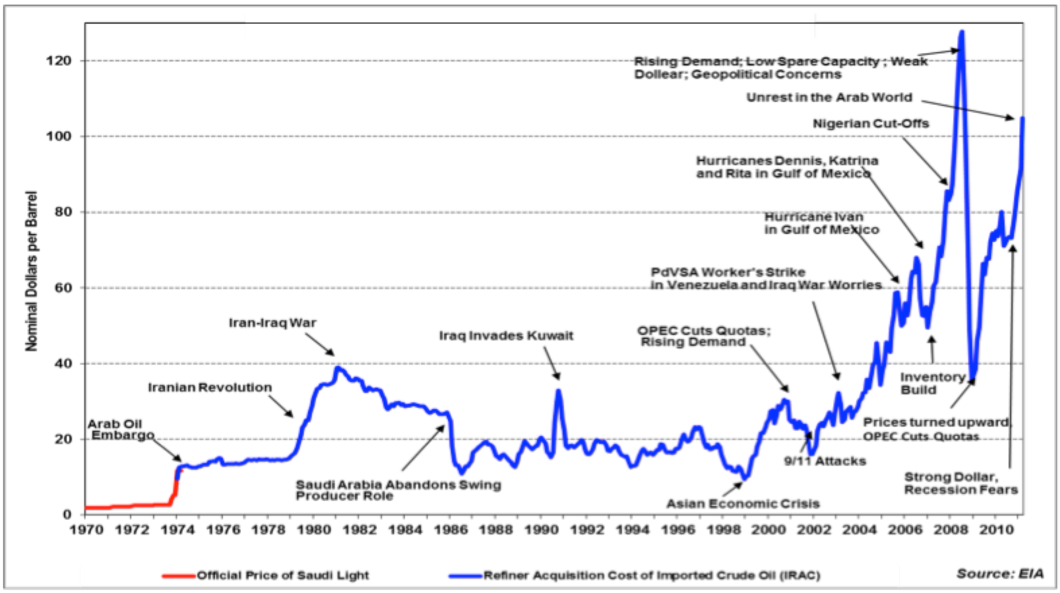
Source: Annual Energy Outlook 2011 Early Release Overview, EIA.

Robust growth in Emerging Economies and Emerging Asia particularly and the consequent rise in oil demand led to crude oil accounting for 19% of total global export value in 2009, according to recent statistics from the World Trade Organization (WTO), underscoring the critical role of crude oil in international trade, energy industry and the global economy.

[1] The EIA's Reference case assumes that limitations on access to energy resources restrain the growth of non-OPEC conventional liquids production between 2009 and 2035, and that OPEC targets a relatively constant market share of total world liquids production.

Figure No. 2 below traces the importance and evolution of oil as a global commodity, summarizing the history of oil prices over 1970-2011, while identifying turning points, relating spikes to specific events and actions, and emphasizing the volatility of oil prices that either contributed to or accompanied shocks in both financial markets and the real economy.

Figure No. 2: Nominal Oil Price Chronology: 1970-2011



Remark: EIA Data and chronology extend until end of 2007 and beyond that is DIFC Economics.
Source: EIA (website: http://www.eia.doe.gov/cabs/AOMC/Overview.html), DIFC Economics.

The 1970s was a turbulent decade in the Middle East, with the first major turning point in 1973, when prices increased to a new record of close to $15 per barrel due to Arab Oil Embargo in that year. The decade of the 1980s witnessed a new high in oil prices to around $40, as a result of uncertainty and supply disruptions as a result of the Iraq – Iran war. The war led to a collapse in prices at the beginning and as oil production from the two countries recovered very slowly during the war the oil price touched low point at $12/barrel in 1986, with Saudi playing the role of 'swing producer'. The Second Gulf War (1990-1991) was the next shock, with Iraqi production collapsing again when the country invaded Kuwait in Aug 1990, also bringing Kuwait's substantial production down with it (together accounting for close to 9% of the world's production).

The Asian financial crisis led to the next sharp drop in oil prices - falling below $12 a barrel by the end of 1998. In real terms, that was the lowest price since 1972, and a price that seems unlikely to be seen again for the foreseeable future. World petroleum consumption returned to strong growth in 1999, and by the end of the year, the oil price was back up to where it had been at the start of 1997. Between 2000 and 2008, strong global demand led to acceleration in oil prices (while supply lagged, increasingly only slowly) to reach the highest-ever nominal oil price of $147 (July 2008). However, this record price did not hold for long as, with Lehman's collapse came the crash of both equity and commodity markets, ringing in one of the worst economic crises since the Great Depression and leading to an OPEC intervention through heavy production cutting.

Scope of the Paper

Currently (May 2011) trading in a range of $100 - $120 a barrel, crude oil is the world's most actively traded commodity while the NYMEX division light sweet crude oil contracts are the largest-volume futures contract trading on a physical commodity. Given extreme fluctuations in the price of crude oil, oil future contracts have become a common tool in commodity markets for hedging and speculating against the oil price volatility.

This paper investigates the efficiency of the Dubai Mercantile Exchange (DME) pricing mechanism between the spot and future prices of its flagship Oman Crude Oil Futures Contract. Research papers have examined the relationship between spot and futures prices especially in New York Mercantile Exchange (NYMEX), International Petroleum Exchange and other commodity markets in advanced economies, but research on commodity markets in developing economies (including DME) have been almost non-existent. Therefore, this seminal paper discussing the market efficiency of the DME oil market will also be a first in the emerging markets region. The aim of this paper is also to show that the inception of the DME has added value to international oil markets, by allowing a more transparent price setting mechanism for oil grades such as those, typically higher sulfur sour and heavier crudes, which are produced in the Arabian Gulf (AG).

Box1: Oil Futures Contracts, Trading & Clearing Houses

Futures contracts including trading in crude oil futures are financial instruments and carry with them legally binding obligations. Buyer and seller have the obligation to take or make delivery of an underlying instrument at a specified settlement date in the future. Oil futures are part of the derivatives family of financial products as their value 'derives' from the underlying instrument. These contracts are standardised in terms of quality, quantity and settlement dates. The bulk of activity in commodity futures markets is typically concentrated on oil for delivery in the next three months. However, in the past five years, activity has increased substantially for deliverives much further into the future as more investors put money into commodity indices.

How Are Oil Futures Traded? Futures contracts are traded on regulated futures exchanges. Trading can take place through electronic dealing systems, open outcry around a pit or a combination of both. To trade on an exchange, you need to be a member of that exchange. Exchange members can trade on their own account or they can execute orders for hedgers or speculators. In the latter case, exchange members are acting as brokers and will collect a fee for their service. Each futures exchange has a clearing house which ensures that trades are settled in accordance with market rules and that guarantees the performance of the contracts traded.

The Role of Clearing Houses

The clearing house, among other roles, is responsible for the management of the risk on transactions on the exchange – it establishes margin levels, default rules and ensures the settling of individual positions. When market participants buy futures, they do not pay the full amount of value of the contracts they purchase. Rather, they pay an initial margin that acts like an insurance deposit (the amount is determined by the clearing house).

This initial margin represents a percentage of the value of the transaction. At the end of each trading day, individual positions are evaluated relative to the closing price of the market published by the exchange – participants are then said to be 'marked to market'.

If their position is profitable, that profit will accrue into their account. In contrast, if the position is not profitable, the loss will be deducted from the initial deposit and the participant will be given a 'margin call' (called the variation or maintenance margin) to make up the difference.

On the settlement date or the expiry of futures contract, the buyer and seller have the obligation to make or take delivery of the instrument. In the case of oil, settlement can be carried out in two ways: through the actual delivery of oil into a predefined location or through a cash settlement. In reality, very rarely does physical delivery take place in commodity futures. At the same time, market participants do not necessarily need to wait for the expiry of their contract to settle their obligation vis-à-vis the exchange.

Positions are often closed by taking an offsetting position for an equal and opposite amount of contracts. For example, a buyer of a certain futures can therefore sell an equal amount of that futures, making their net obligation relative to the exchange zero.

Source:
http://www.liveoilprices.co.uk/oil-futures-faq.html

Overview of DME

The Dubai Mercantile Exchange (DME), which was launched in June 2007, is located within the Dubai International Financial Center (DIFC) and regulated by the Dubai Financial Services Authority (DFSA). The DME is the first exchange in the Middle East to offer sour crude contracts, and with its base in the Middle East, close to the source of the physical product, the DME is well placed. After the Intercontinental Exchange (ICE) in UK started to offer a sour crude product starting May 21, 2007, Dubai was the second exchange to offer the product with strategic objective of providing a fair and transparent price discovery mechanism for crude grades exported to Asia. The DME and ICE were hence creating the availability of a product for which there was demand but had previously been no supply.

DME Oman is the sole benchmark for Oman and Dubai crude oil official selling prices. DME lists the Oman crude oil futures contract providing a market based crude oil benchmark price for the East of Suez region.[2] Despite the relatively small volumes of oil traded on the DME compared to other international financial markets like NYMEX, the significant role of DME derives from the fact that the region's crude grades use prices of Omani crude as the basis of pricing crude exports to Asia. Being 'light' or 'sweet crudes' Brent and WTI prices are no longer ideal reference for price discovery for sour crude oil export to Asia. Despite this, some countries like Yemen, Iraq and Iran continue pricing oil exports to Asia on the basis of Brent and WTI prices. As the market builds, the DME futures price is likely to become the most reliable source of sour crude prices for the Middle East and Asia markets in the future. The table below displays key statistics on key crude oil exports of Arabian Gulf region that use Oman oil prices as benchmark.

Table 1: Volume of crude oil exports in GCC region to Asia (unit 1,000 b/d)

Time	Kuwait	Qatar	KSA	UAE	Oman	% of OPEC	% of World
1995	706	319	2,757	1,829	785	33.8	19.8
1996	720	345	2,818	1,844	810*	34.0	19.6
1997	685	454	2,769	1,847	835	32.6	19.0
1998	724	561	2,699	1,959	825	31.4	18.2
1999	647	546	2,547	1,875	846	31.7	17.8
2000	699	563	2,902	1,778	667	30.7	17.0
2001	739	562	2,954	1,724	594	32.1	17.3
2002	803	555	2,622	1,575	608	32.7	17.3
2003	952*	545*	3,040*	1,856*	638	34.8	18.8
2004	1,101	536	3,458	2,137	718	34.7	19.9
2005	1,381	547	3,937	2,140	722	36.8	21.5
2006	1,416	619	3,957	2,351	763	38.2	22.4
2007	1,347	615	3,990	2,277	838	37.2	22.2
2008	1,438	703	4,282	2,271	908	39.7	23.9
2009	1,162	647	4,070	1,868	895	39.0	22.4
Average (95-09)	968	541	3,253	1,955	763	34.6	19.8

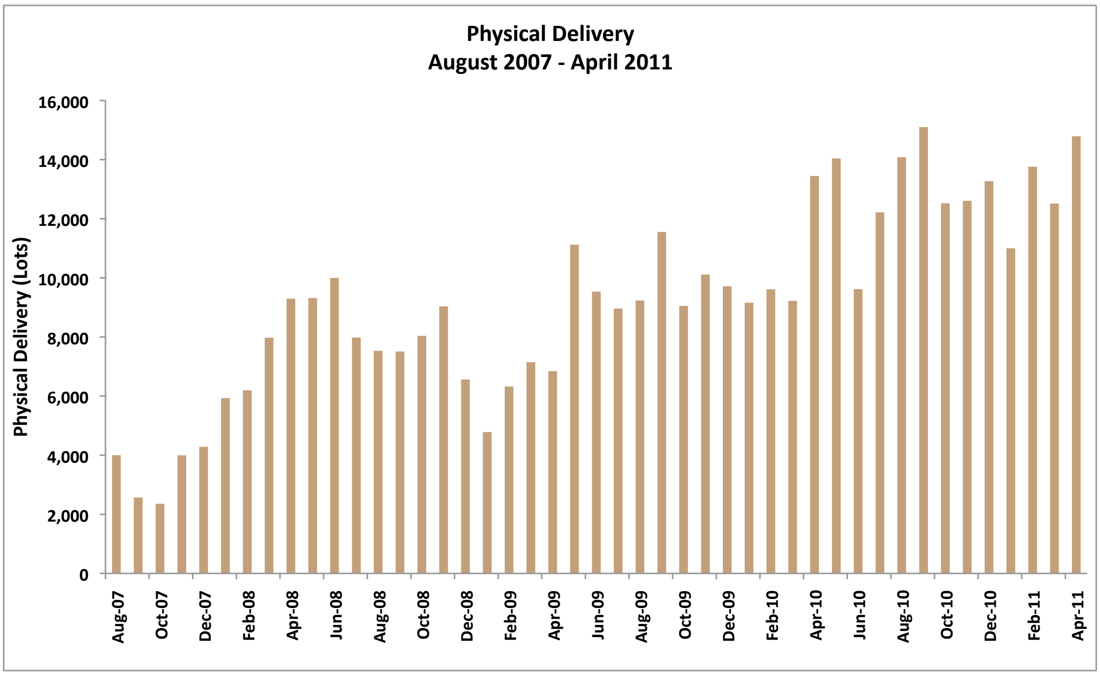
Remark: * refers to estimated data by average.
Source: OPEC Annual Statistical Bulletin, National Statistical Authorities

[2] For a useful reference source on oil derivatives markets, see "The Mechanics of the Derivatives Markets", a Special Supplement to the IEA's April 2011 Oil Market Report, http://omrpublic.iea.org/special_sup_apr11.pdf.

Table No. 1 shows that more than 35% of OPEC crude oil exports and 20% of international crude oil exports adopt Omani crude prices as benchmark, underscoring the key role of DME oil prices in the international oil market.[3]

The DME is a fully electronic exchange and its contracts are listed on CME Globex as well. DME has 22 clearing members who are also NYMEX clearing members. There are 27 off-floor members and 7 equity members as of first of April 2011. Additionally, DME Oman is the largest physically delivered crude oil futures contract in the world with an average of 12 million barrels per month delivered through the exchange in 2010. Since its launch in June 2007, over two billion barrels of Oman crude oil have been delivered through the DME (Figure No. 3).

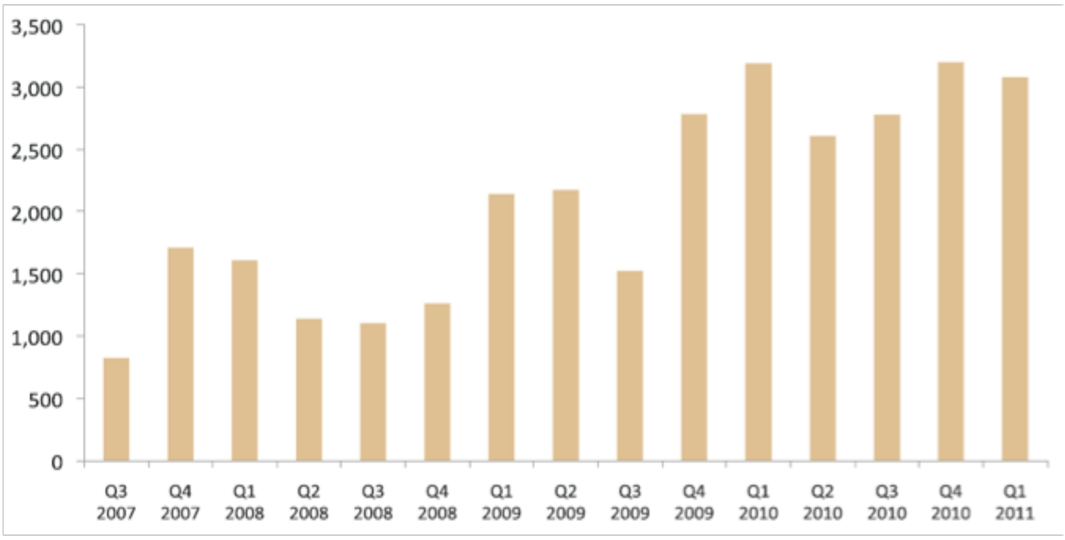
Figure No. 3: DME Oman Physical Delivery



Source: Dubai Mercantile Exchange.

[3] American Petroleum Institute (API) classifies crude oil as light, medium or heavy, according to its measured API gravity. Light crude oil is defined as having API gravity higher than 31.1 °API, (less than 870 kg/m3). Medium oil is defined as having API gravity between 22.3 °API and 31.1 °API, (870 to 920 kg/m3). Heavy oil is defined as having API gravity below 22.3 °API, (920 to 1000 kg/m3). Extra heavy oil is defined with API gravity below 10.0 °API, (greater than 1000 kg/m3). www.api.org/

Figure No. 4: DME Average Daily Volume by Quarter (Lots)



Source: Dubai Mercantile Exchange.

Box2: DME Oman Crude Oil Futures Contract Summary (OQD)

Trading Unit:
1,000 U.S. barrels (42,000 gallons)

Price Quotation:
U.S. dollars and cents per barrel

Trading Symbol:
OQD

Trading Hours:
Electronic trading is open from 1800 U.S. Eastern Standard Time (EST) and closes at 1715 EST the next day, Sunday to Friday. Singapore is 13 hours ahead of EST and Dubai is 9 hours ahead. The time difference is reduced by one hour when Daylight Savings Time is in effect. Neither Dubai nor Singapore observes Daylight Savings Time.

Trading Months:
The current year and the next five years will be listed. A new calendar year will be added following the termination of trading in the December contract of the current year.

Minimum Price Fluctuation:
$0.01 (1) per barrel ($10.00 per contract)

Maximum Daily Price Fluctuation:
None

Daily Settlement:
A daily OSP settlement price will be published as at 1630 (Singapore) 0330 or 0430 EST. This price represents the weighted average price of trades in the nearby Contract Month between 1625 and 1630 (Singapore).

Box2: DME Oman Crude Oil Futures Contract Summary (OQD) *(continued)*

The DME will also publish an end of trading day settlement price for all listed Contract Months, determined as at 1430 EST, which coincides with the end of the trading day for NYMEX Light Sweet Crude Oil. This latter settlement price is used by the Clearing House to calculate daily variation margin on all open DME Contracts.

Final Settlement Price:
The Final Settlement Price for a Contract Month shall be the OSP settlement price on the last Trading Day of the Contract Month. This price represents the weighted average price of trades in the nearby Contract Month between 1615 and 1630 (Singapore).

The Final Settlement Price will be used for purposes of margins for delivery of the Oil.

Last Trading Day:
Trading in the nearby Contract Month shall cease on the last Trading Day of the second month preceding the Delivery Month.

Settlement Type:
Physical

Delivery:
F.O.B at the Loading Port, consistent with current terminal operations. Complete delivery rules and provisions are detailed in Chapter 10 of the rulebook.

Governing Law:
English Law

Source: DME website (http://www.dubaimerc.com/trading/contact-summary/oqd.aspx)

What is market efficiency?

Market efficiency analysis is research oriented towards determining the degree to which, at any point of time, market prices (of assets, securities, commodities) reflect all available, relevant information. If they did not there would be arbitrage possibilities and the opportunity to make above normal profits or abnormal returns on investment. In particular, the efficient-market hypothesis as exposited by Fama (EMH)[4] asserts that financial markets are "informationally efficient". That is, a market participant (trader, investor etc.) cannot consistently achieve returns in excess of average market returns on a risk-adjusted basis, given the information publicly available at the time the investment is made. Determining market efficiency includes specifications of the nature of the market, industrial organisation, transaction and storage costs (relevant for commodities), production technology, market players preferences concerning risk, and other information that help towards understanding the transaction pricing mechanism.

Market efficiency has three forms: (1) weak-form efficiency, (2) semi-strong-form efficiency and (3) strong-form efficiency according to the information set available to agents, as discussed above. Professor

[4] See Fama, Eugene (1970). "Efficient Capital Markets: A Review of Theory and Empirical Work". Journal of Finance 25 (2): 383–417.

Fama, who developed the efficient-market hypothesis concept in the 1970s[5], defined the three types of efficiency, differentiating them by what information were factored in the price.

Under the weak form efficiency, there is no information in past prices which will allow an investor to earn abnormal returns based on that information. Prices fully reflect historical trends, thus making it impossible to profit from past information on prices, volumes and related information and their patterns.
The semi-strong form maintains there is no publically available information that will allow an investor/trader to earn abnormal returns based on that information. That all public information such as companies' announcements or annual earnings figures are reflected in prices already, and if any new information comes in, this is immediately reflected in the prices. Finally the strong-form maintains that there is no public or even private information that will allow an investor to earn abnormal returns based on that information. In effect, through their actions agents' information, including private, is incorporated in price. Even insider information can not entail profits, i.e., Insider trading cannot make profits under strong-form market efficiency.

The problem with testing for market efficiency is that one is always testing a joint hypothesis. Fama introduced the concept of a joint hypothesis problem: any test of efficient markets hypothesis (EMH) is a joint test of market efficiency (in the above three forms) and must assume an equilibrium model. "First, any test of efficiency must assume an equilibrium model that defines normal security returns. If efficiency is rejected, this could be because the market is truly inefficient or because an incorrect equilibrium model has been assumed. This joint hypothesis problem means that market efficiency as such can never be rejected." Campbell, Lo and MacKinlay (1997), page 24

Box 3: Literature Review

This box focuses on the key findings of market efficiency researches, particularly in the oil market – mostly testing for the weak form of market efficiency.

Bopp and Sitzer (1987) examined the relationship between futures prices and cash prices for oil traded in on the New York Mercantile Exchange regardless of other market information. The results proved that futures prices are useful for estimating the spot prices. The major drawback of the study was its methodology - based on the ordinary least square regression technique.

Later research papers have applied the unit root tests (pioneered by Dickey-Fuller in 1979) for testing stationarity of oil prices. Sivapulle and Moosa (1999) applied a unit root test to daily WTI spot and futures with different maturities for period 1985 - 1996 concluding non-stationarity. Taback (2003) tested for a unit root in Brent spot and futures prices, concluding that both spot and futures prices were non-stationary. Serletis and Rangel-Ruiz (2004) followed the same test for 1991 - 2001 finding that the null hypotheses of a unit root cannot be rejected. Coimbra and Esteves (2004) excluded the impact of the Gulf

[5] "The efficient markets hypothesis (EMH) suggests that profiting from predicting price movements is very difficult and unlikely. The main engine behind price changes is the arrival of new information. A market is said to be "efficient" if prices adjust quickly and, on average, without bias, to new information" The Efficient Markets Hypothesis by Clarke.

Box3: Literature Review *(continued)*

war while testing for stationarity in 1989-2003, finding that the null hypothesis of a unit root in crude oil prices cannot be rejected. Recently, Maslyuk and Smyth (2008) examined the efficiency of crude oil markets by analyzing the weekly spot and futures prices for both US West Texas Intermediate (WTI) and UK Brent by using Lagrange Multiplier unit root tests allowing for one and two structural breaks and concluded that each of the series followed a random walk process.

Serletis and Banack (1990) tested market efficiency by applying a cointegration analysis on daily data for the spot and 2-month futures prices of crude oil, gasoline, and heating oil traded on NYMEX and found evidence consistent with this hypothesis. Crowder and Hamed (1993) and Sadorsky (2000) tested the simple efficiency hypothesis on NYMEX and the arbitrage conditions for crude oil futures using co-integration and concluded that the speculative efficiency hypothesis could not be rejected.

Data Analysis

This paper uses DME data available from its inception to test for the weak form of market efficiency. The data limitation constrains us to focus on the weak form – which is also the most researched, as per our literature review. The weak form posits that no return is possible from arbitrage between spot and future/forward prices assuming there is no cost for storage and transaction, market participants are risk neutral, the market is monopolistic competitive, and information is available and used rationally.

Define St as the spot price of DME oil market at time t and Ft,k the future price of DME oil market for k periods ahead, traded at time t. The weak form market efficiency implies that the spot price at time t+k is equal to future price at time t:

$$(1)\quad F_{t,k} = E(S_t + _k/\theta_t)$$

where indicates the expected price at time t+k, given some information set θ_t at time t.

The DME oil market efficiency was tested for future contracts with maturity up to four months. Daily observations for the future prices (up to four months) of DME oil contracts were obtained from Bloomberg. One important issue that needs to be clarified is the spot prices of oil contracts. Since there is no real spot price with immediate or current delivery, such as seen in the foreign currency market, the first future price is defined as the spot price since it is nearest to the delivery date. A weekly series was hence constructed by taking the prices of the first trade date in each week. In case of non-trading days, the last observation was carried over to fill in the missing value.

Three prices type are available for DME oil contracts:

(a) The Daily Settlement Price is the weighted average of all trades that take place during the closing range which is a five minute window from 16:25-16:30 (Singapore) except the last trading day of the month when the 15 minutes range from 16:15 to 16:30 (Singapore).

(b) The Daily Post Close Price is calculated and published at 2.30 PM New York time, which is used by the Clearing House to mark to market open positions and thereby establish variation margin.

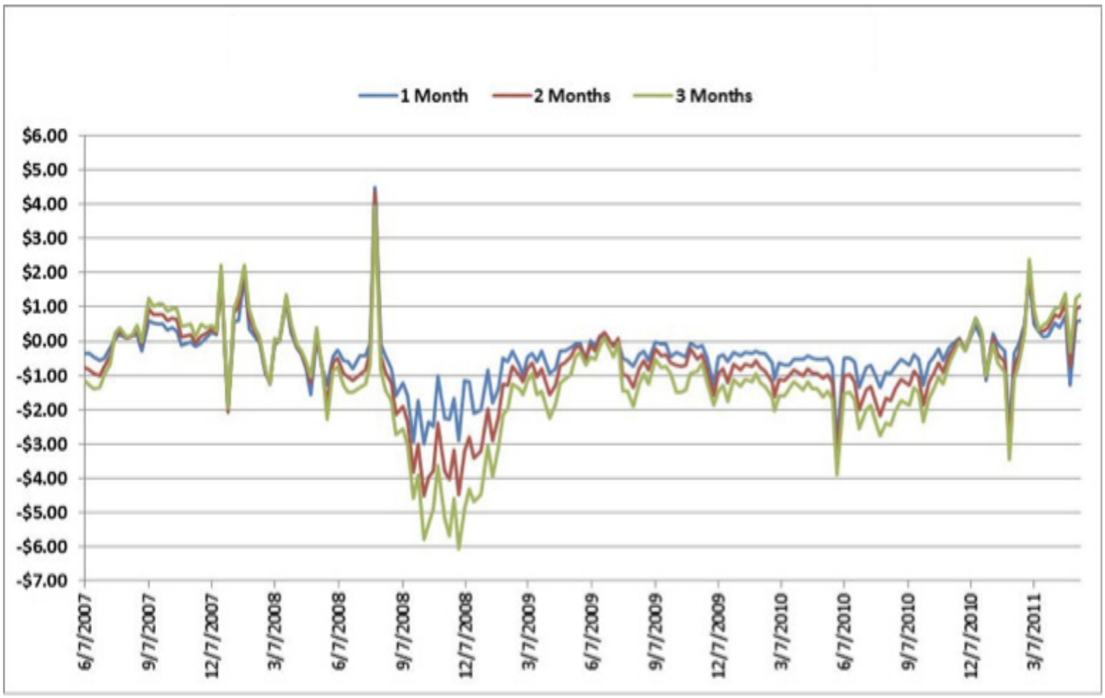
(c) The Final Settlement Price is the oil settlement price (OSP) on the last Trading Day of the Contract Month.

The reason to not test future contract with maturity more than four months is because the contract is not liquid at longer time horizons, raising issues of market thinness[6]. The volume and open interest of the future contract confirms the illiquid nature of future contracts beyond fourth months. The trading volume and number of open interest drops significantly after the fourth month indicating limited activity and illiquidity of the futures contract.

The premium at the DME is charted below highlighting the difference between the realized price (i.e. spot) and the expected price (i.e. futures). The gap widens during the period Q3 2008- Q1 2009, when global sentiment weighed in on market players regarding future expectations of oil price. The market was stable until pre-financial crisis time, after which uncertainty led to a gap and has recently returned to the pre-crisis levels.

[6] The New Palgrave Dictionary of Economics defines a thin market, as "a market with few buying or selling offers. The concept of market thinness, while general, is typically used in the context of financial markets. When the number of buying or selling offers is small, investors' trading positions are large relative to market size. Trading then requires price concessions and thus exerts an impact on prices. A thin market is characterized by low trading volume, high volatility and high bid–ask spreads."

Figure No. 5: The Premium of DME Oil Price



Source: Bloomberg.

Figure no. 6 below displays the spread - calculated as the difference between the spot price in future traded month and the future price in present traded month. This displays a quick analysis as to the efficiency of the market, before embarking on the econometric testing. In the figure, the spread for one month remained around 0 while the average of absolute value of spread was close to 3; spread for two months moved away from zero, with some volatility during the Q2 2008 – Q1 2009 period, and its absolute average was 10. In contrast the three month spread was quite divergent with absolute average of 14. The source of noises are the inflation period when the commodity prices surged in 2Q2008 - 3Q2008 and the crisis period when the commodity price declined after a sharp decline in equity markets in 4Q2008 – 1Q2009. If this outlier period is excluded, then the results will be more robust. Similar analysis was done by Coimbra and Esteves (2004) - who eliminated the oil price surge during Kuwait invasion in testing the relationship between the spot and futures prices of Brent oil crude. The authors constructed partial sample that excludes the Gulf War effects. However, it is important to not exclude the crisis period in the market efficiency analysis because this will influence the results and will not give a meaningful conclusion.

Figure No. 6: The Spread of DME Oil Price

Source: Bloomberg.

Furthermore, the volatility of prices has been tested to reinforce the market efficiency theory and support the conclusions above. Figures below display the distribution of the prices volatility for the spot and the next three future contracts which follow a normal distribution. The figures show concentration of returns around zero and the thin tails are consistent with the absence of abnormal returns and of market efficiency.

We also examined the relationship of trading volume and volatility, since there could be implications of trading volume for movements in prices and it also could be considered as information set in a semi-weak form of the market efficiency hypothesis. The reason to determine this specific factor among other information set like news is supply (volume) and demand (price) always determine the settlement prices.

Consequently, it was important to ensure that trading volume does not affect the prices. Liquidity (volume) factor could affect the equilibrium model and rational expectation for the market efficiency hypothesis. The empirical results of simple linear regression and the causality test suggested the trading volume is irrelevant to price movements (Table No.2). Therefore, the market efficiency test will be restricted to prices.

Figure No. 7: Distribution of Price and volume volatility

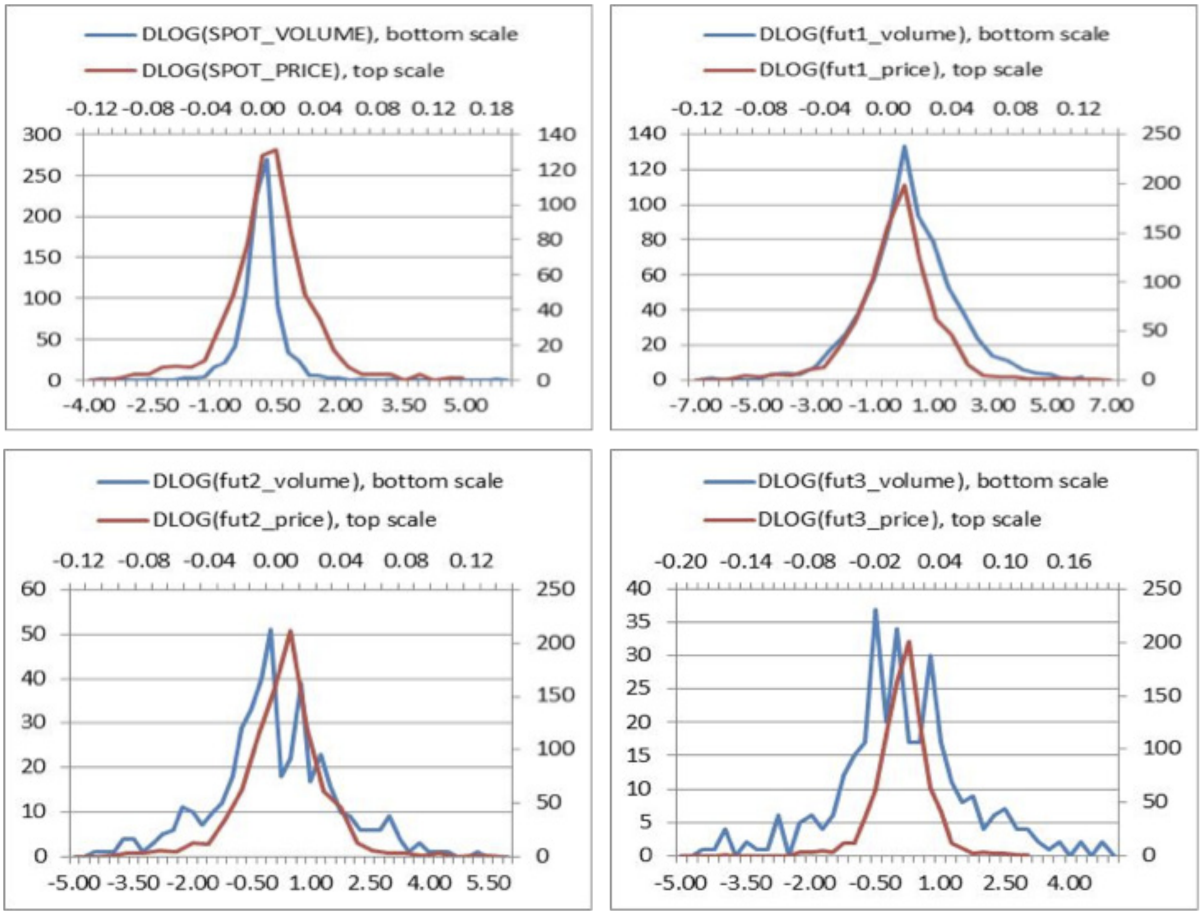


Table No.2: P- Value of Statistical test between the prices volatility and trading volume of the future contracts

P Value / Contract	Spot Contract	1M Future Contract	2M Future Contract	3M Future Contract
Simple linear test	0.5482	0.0710	0.0975	0.4693
Granger causality test	0.9803	0.4488	0.6825	0.5214

Most research papers referred to in the literature review section cited a natural problem existing in the data, while attempting to examine the relation between the future and spot prices. Hansen & Hodrick (1980) introduced overlapping observations over the sample period - known as serial correlation in prediction errors which will produce spurious results. This occurs when the horizon of sampling interval time falls within the forecast interval time.

To explain this, the following example is useful. Assume the current trading month is December 2010 and a market participant is predicting the spot price for contract February 2011, which is two months ahead.

The spot price in February 2011 will also be influenced by all market information - including the spot prices in January and February 2011. Similarly, the spot price in March 2011 time will be influenced by market information in the previous and current month and so on. The table below displays how the overlapping problem on future contracts is dependent on how the current spot price.

Table No. 3: DME Oman Crude Oil Futures Contract Trade Datesv

Trading Month	Last Trading Date	Delivery Month	Spot Month	Future 1 Month	Future 2 Month	Future 3 Month
Dec 2010	Dec 2010	Feb 2011	Feb 2011	Mar 2011	Apr 2011	May 2011
Jan 2011	Jan 2011	Mar 2011	Mar 2011	Apr 2011	May 2011	Jun 2011
Feb 2011	Feb 2011	Apr 2011	Apr 2011	May 2011	Jun 2011	Jul 2011

While using an ordinary least squares technique for regression, the variance of residuals needs to be serially uncorrelated: $(cov(e_t,e_s)=0)$. In the presence of serial correlation, the covariance estimator is inconsistent, leading to a bias in the t-test, also limiting and misleading statistical inference about the parameters.

To overcome this difficulty, Hansen and Hodrick introduced a correction estimation of the covariance matrix (discussed in detail in the next section). However, other researchers argued that by defining a non-overlapping sample or reducing the sample size (e.g. seasonality effects can be eliminated by using annual data, but this reduces the number of observations) could avoid this overlapping problem[7]. Additionally, while using the weak form of efficiency, taking out observations will limit the use of the only source of data available. Tabak (2003), argues that the overlapping problem could be avoided by taking the closing price on first trading day preceding the contract expiration without sacrificing observations. This argument is valid for monthly data and limited to the future contract with one month maturity. In case of long future contract the argument seems flawed because when the current future contract ceases, a new future contract will immediately replace the expired one and the quoted data will be for the new contract.

Estimating Model

The model below represents the weak-form of market efficiency:

$$(2)\quad S_{t+k} = a + \beta f_{t,k} + \varepsilon_{t+k},\ t = 1, \ldots, T$$

where S_{t+k} is a spot price at time t+k and $f_{t,k}$ is a future price at time t for k period ahead, ε_{t+k} is a prediction error, β is a coefficient of model that needs to be determined and t is the size of sample period.

Since the model is to test no change in prices – i.e. E(S_{t+k}) = $f_{t,k}$ the mean forecast errors have been calculated for out-of-sample (Jan 2011 – Mar 2011) as displayed below. The mean forecast errors show how the predicted data are close to the actual data and this is in line with testing change in prices.

[7] A complete reference of the overlapping data problem could be found in the Overlapping Data Problem by Harria and Brorsen published in the Quantitative and Qualitative Analysis in Social Sciences.

Table No. 4: Mean forecast errors for future contracts

Model	Mean forecast errors
Future 1 Month Contract	2.30
Future 2 Month Contract	2.40
Future 3 Month Contract	3.66

The out of sample period, the first quarter of 2011, incurred dramatic changes in oil prices due to the regional unrest and popular uprising in the Arab World. Despite that the errors seem to be relatively small and the errors increase as the contract period increased reflecting the market tensions.

The OLS output of equation 2 with the three future contracts are listed in appendix A (Refer to tables A1-A3). Since the two variables trended strongly, the cointegration test was conducted to check for stationarity. The Augmented Dickey-Fuller (ADF) output shows that the tau-test statistics is greater than critical values for all significant levels. Based on that, the null hypothesis, that the residual of equation 2 has a unit root cannot be rejected – confirming the existence of a unit root and that either both variables or one of them is non-stationary.

Based on these initial findings, the data have been transformed by taking the first difference and a unit root test was conducted for the transformed series. The output of the test indicated the unit root problem was solved by transforming the series[8].

The next step is to determine whether the market is efficient or not. The null Hypotheses (ß = 0) would imply that no relationship exists between the spot and future prices while the alternative hypothesis (ß ≠ 0) denotes that there is a relationship between the prices.

$$H_0: \beta = 0$$
$$H_1: \beta \neq 0$$

Fama's approach, which is followed by many researchers, tests whether the ß is significantly different from zero or not. Based on this test, it is decided if the observed future prices contain information about the predicted spot prices. However, some researchers recently introduced a new approach to test market efficiency. Crowder and Hamed (1993) argued that if the futures prices are considered an unbiased predictor of realized spot prices, then this should imply coefficients of a = 0 and ß = 1. Consequently, this can be interpreted as futures prices at current time contain all relevant information necessary to forecast spot prices in the future. This paper follows Fama's methodology

[8] Unit Root Test Output:

Table No. 5: Unit Root Test		
Equation Form	Test for unit root in level	Test for unit root in 1st difference
1 month future	-2.601511 *	-9.987203 ***
2 month future	-2.729300 *	-4.706628 ***
3 month future	-2.748881 *	-14.58793 ***

Remark: 1. the test type is Augmented Dickey-Fuller
2. the equation form includes trend and intercept.
3. * indicates insignificant with the tau value is greater than all the critical values for all significant levels
4. *** indicates significant with tau value is less than critical values for all significant levels

because the second approach is flawed for the following reason: Crowder and Hammed in their argument assumed a perfect linear relationship while the market efficiency theory does not specify the form of the relationship. In other words, if the equation followed an inverse relationship, a 1 unit decrease of one factor will lead to one unit increase of another or if the relation between the factors was double – a 2 unit change will lead to 1 unit change: this is not an efficient market according to previous argument.

As was highlighted previously, due to the existence of the overlapping problem, the Hansen and Hodrick (HH) test is used to correct the standard error of the slope estimator (β). The results are as follows[9]:

Table 6: Estimates of β & δ

Equation form	Estimates of β by OLS	Estimates of δ by HH
1 month ahead	0.05616 *** (0.075186)	7.785842 * (0.943830)
2 month ahead	-0.025958 *** (0.076741)	10.447120 * (0.978238)
3 month ahead	-0.054142 *** (0.077841)	9.528824 * (0.978238)

*Significant at the 5 percent level (t-test: β=0, chi-square test: δ = 0)
*** Not Significant at the 5 percent level (t-test: β=0, chi-square test: δ = 0)

Table 6 shows the estimates of β under two estimation techniques for the three months horizon. The first column shows the results of the ordinary least square errors technique and the standard error are in parentheses. The second column shows the result of the Hansen and Hodrick technique which was displayed earlier and its standard error values in parentheses.

The analysis conducted in the previous section indicates that the null hypothesis (regression coefficients are zero) is not rejected for the short term future contracts by the usual regression technique which is the ordinary least square, but the null hypothesis is rejected when the Hansen and Hodrick technique was used. The second test is more reliable due to biased standard error in the usual regression methods as has been discussed previously.

Based on these results, the market efficiency in a weak form cannot be rejected for these future contracts.

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[8] The HH Test follows the below process:

1. Estimate the residuals e_t by using OLS regression and rename the residuals to $\{u_1,\ldots, u_t\}$.
2. Calculate C_j by $C_j = \sum_{t=j+1}^{T} u_t u_{t-j} \,/\, T$
3. Calculate H which is given by $H = T(X'X)^{-1}X'CX(X'X)^{-1}$

where H denotes HH variance-covariance matrix calculated by above formula, C which is a matrix whose lower triangular is given by

$$C = \begin{bmatrix} c_0 & & & & & & \\ c_1 & c_0 & & & & & \\ \vdots & \ddots & \ddots & & & & \\ c_{k-1} & \cdots & \ddots & \ddots & & & \\ 0 & \ddots & & \ddots & \ddots & & \\ \vdots & \ddots & \ddots & & \ddots & \ddots & \\ 0 & \cdots & 0 & c_{k-1} & \cdots & c_1 & c_0 \end{bmatrix}$$

and X which is a vector

$$X = \begin{bmatrix} x_1 \\ \vdots \\ x_T \end{bmatrix}$$

4. Approximately, $\delta = T(b-\beta)'H^{-1}(b-\beta)$ follow the x^2 distribution with degrees of freedom equal to parameters number.

However, the R-square remains low and since the model is bound by the weak-form assumption, no other explanatory variables can be added to improve the model goodness of fit. The only option left in the weak form was to use different functional forms like exponential model, log model and other nonlinear model. Most researches assume the simple linear relationship between the future and spot prices. Several tests were conducted over the exponential and log equation form, but the results have led to no significant difference in conclusion.

Conclusion

The establishment of the Dubai Mercantile Exchange and the trading of the Oman Crude Oil Futures Contracts was both innovative and brought high value added to the international oil markets. Until then, the pricing regime of the regional crude exports to the Asia markets was determined by the WTI or Brent futures prices. However, WTI and Brent are 'sweet crudes', with different crude grades and specifications than the 'sour crudes' of the region including Oman and Dubai crude. In the past there were several attempts to create such a market, but none of them were successful, because a futures market needs to satisfy a number of conditions relating to the trading mechanism and platform, price discovery process, nature and specification of the contract, competition, trading volumes etc. Otherwise it will not gain ground in the international markets.

This paper provided an introduction and description of the DME, its contracts, membership and operations. We conducted extensive empirical testing relating to the efficiency of the DME in pricing the Oman crude contract. Our empirical results are consistent with the hypothesis that the DME oil market is efficient for future prices up to three months. This conclusion matches most empirical research on efficiency in the markets for the pricing of WTI and Brent crude. In particular, our result show that the DME future prices, over the period June 2007 to April 2011, satisfied the necessary conditions to perform the role of price discovery and to play the role of a benchmark in pricing Middle East and international oil prices. The efficiency of the DME should encourage other oil producers in the region to switch away from using Brent to price their exports to Asia and adopt Oman/ Dubai crude prices, that provide the more suitable and robust benchmarks for crude oil exports to Asian markets.

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Appendix A: Regression Results

Table A1:
OLS Regression output of equation 2 for one month future contract

Dependent Variable: D(SPOT(4))
Method: Least Squares
Date: 05/18/11 Time: 18:18
Sample (adjusted): 2 186
Included observations: 185 after adjustments
D(SPOT(4)) = C(1) + C(2)*D(FUT1)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.194484	0.309485	0.628412	0.5305
C(2)	0.056160	0.075186	0.746943	0.4561

R-squared	0.003039	Mean dependent var	0.209189
Adjusted R-squared	-0.002408	S.D. dependent var	4.195882
S.E. of regression	4.200932	Akaike info criterion	5.719242
Sum squared resid	3229.552	Schwarz criterion	5.754056
Log likelihood	-527.0299	Hannan-Quinn criter.	5.733351
F-statistic	0.557924	Durbin-Watson stat	2.091590
Prob(F-statistic)	0.456057		

Table A2:
OLS Regression output of equation 2 for two months future contract

Dependent Variable: D(SPOT(8))
Method: Least Squares
Date: 05/18/11 Time: 18:19
Sample (adjusted): 2 182
Included observations: 181 after adjustments
D(SPOT(8)) = C(1) + C(2)*D(FUT2)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.233047	0.315521	0.738611	0.4611
C(2)	-0.025958	0.076741	-0.338250	0.7356

R-squared	0.000639	Mean dependent var	0.227348
Adjusted R-squared	-0.004944	S.D. dependent var	4.228401
S.E. of regression	4.238842	Akaike info criterion	5.737445
Sum squared resid	3216.232	Schwarz criterion	5.772788
Log likelihood	-517.2388	Hannan-Quinn criter.	5.751774
F-statistic	0.114413	Durbin-Watson stat	2.042304
Prob(F-statistic)	0.735571		

Table A3:
OLS Regression output of equation 2 for three months future contract

Dependent Variable: D(SPOT(12))
Method: Least Squares
Date: 05/18/11 Time: 18:20
Sample (adjusted): 2 178
Included observations: 177 after adjustments
D(SPOT(12)) = C(1) + C(2)*D(FUT3)

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.217302	0.321307	0.676307	0.4997
C(2)	-0.054142	0.077841	-0.695553	0.4876

R-squared	0.002757	Mean dependent var	0.207627
Adjusted R-squared	-0.002942	S.D. dependent var	4.264439
S.E. of regression	4.270706	Akaike info criterion	5.752671
Sum squared resid	3191.813	Schwarz criterion	5.788559
Log likelihood	-507.1113	Hannan-Quinn criter.	5.767226
F-statistic	0.483794	Durbin-Watson stat	2.060327
Prob(F-statistic)	0.487631		

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