UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, DEHRADUN

Dissertation

Hedging fluctuations in Bunker Prices of Singapore, Fujairah & Mundra Ports

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Student Declaration

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which has been accepted for the award of any other degree or diploma of the university or other institute of higher learning, except where due acknowledgment has been made in the text.

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(_____)
Vineet Kumar Rai

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CHAPTER 1 INTRODUCTION

Shipping is assumed to be one of the risky business and its market is very much volatile. Various players are there in the shipping market such as ship owners, ship operators and other parties need to manage these risks which occurs from the fluctuations in bunker prices, freight rates, interest rates, foreign exchange rates and prices of the vessel fluctuations affect the cash flows of ship owners and ship operators this lead to less cash flow in their accounts.

Earlier bunker costs was not taken into *consideration* but now it has turned into the major problem for the ship owners.

According to bunker cost studies it has been proved that bunker oil plays a vital role in the shipping industry. Bunker oil account for 47% or sometimes even 50%. Any change in Dollar rate lead to
-/+5$ change in bunker prices.

Now many ways are there to reduce the fluctuation in bunker costs. Fixing the shipping routes in advance at a prescribed at an agreed speed and certain kind of ship, it is requirement of managing bunker costs is to reduce and control arising from the fluctuations of bunker prices which reflect the balance of supply and demand of bunker level.

Managing the bunker cost fluctuation is most important activities in shipping company to make a profit. Bunker price is becoming less predictable and fluctuates very much even in a very short period of time.

Managing bunker price effectively and reducing is a tough job risk?

Hedging bunker price fluctuation is the best method to solve this question moreover in this dissertation more focus has been given to overcome the issues related to hedging bunker prices.
Hedging, through forwards, future, swaps, cross hedging etc.

Objectives

The objective of the dissertation is to suggest an appropriate market where to hedge and the suitable hedging instruments for ship owners and operators in hedging their bunker price fluctuation so that it bring optimal hedge ratio and hedging effectiveness. Number of hedging instruments are then carefully examined in order to find out which instrument is best suitable for bunker hedging.

Hedging bunker price requires good understanding of bunker price behavior, not only the spot price but also the futures price. As a result, of this dissertation is to provide a brief account of the development of bunker market and do economic analysis of the factors of the supply and demand of bunker.

Dissertation offers a review of the literature on applications of hedging methods to shipping and particularly in hedging bunker price.

Investigating the effectiveness of hedging requires large data sets of last few years, international seaborne trade, oil price, freight rates, world tonnage, speeds and fuel consumption of ships as well as bunker prices.

- Study the bunker prices of the following port Singapore, Fujairah & Mundra.
- Looking for a suitable market place among the three ports (where to hedge) in order to mitigate the effect of risk in price fluctuation of bunker.
- To apply the hedging techniques on Singapore, Fujairah & Mundra port to mitigate the risk.
- Understand the behavior of bunker price fluctuation & knowing how to hedge the bunker price fluctuation in day to day transaction.
- Investing the effect of hedging require large data I order to use hedging instrument data like economic condition of the various countries, international seaborne trade, bunker oil prices, crude oil prices freight rates, speed of vessel, world tonnage & fuel consumption.
- Testing the efficiency of hedging instruments to bring the accurate picture of the risk mitigation of the price fluctuation in the bunker prices.

Methodology

Quantitative data is used in carrying out studies on hedging and can be found in two areas: secondary research and primary research.
Secondary research consist the acquisition of knowledge of hedging in general and hedging in shipping industry.

The research design used is the Exploratory Research. Exploratory Research is carried out in the beginning of the research process. It is done to contract the scope of the topic and to change the unclear problems into definite ones.

The data is collected using the Secondary Research. Secondary research involves secondary data. Data implies data which exists already i.e. the information which is already collected and worked by someone. During the secondary data is collected one should find out the sources from where the data can be collected. Secondary data includes information that is either published or data that are unpublished would also do. The published data usually be available from sources like books, journals, magazines, report done by students or universities, publications by government be it local, state or foreign government etc. Unpublished data can be made available from say diaries, biographies, research paper, letters, etc.

For searching of secondary one should do the examination of the data properly that the data might be inadmissible or might be lacking in the connection of the issue which the analyst need to contemplate.

Here the various secondary data that I have used are data related to shipping say spot price, freight rates, future prices of bunker, oil prices, seaborne trade, refining capacities of Singapore and other countries, fuel consumption etc.

CHAPTER 2 LITERATURE REVIEWS ON HEDGING IN THE SHIPPING INDUSTRY

Spot market, future market and hedging

The **spot market** is a market where goods are sold on cash basis and delivered immediately. The spot market is also called the *physical market* because prices are settled in cash on the spot at current market price.

The **future market** is a market where buyer/seller exchange contracts for the future delivery of commodities or financial instruments. Contracts on the futures market are standardized and effective at a specified future date. The **future price** is the price for delivery at a specified future date.

Hedging versus speculation

Hedging can be defined as "the taking of a futures position to reduce price risk" –this futures position is opposite to the one that the hedger has had on the spot market, or "a risk-shifting activity". The hedge is effective only when the price risks are offset.

Speculation is a process in which the speculator without any physical positions, takes a position in the future for the purpose of earning possible speculative profits. It can be understood that a speculator is the one who does thing in his own expectation, if he expects that the price will increase in the future he will then buy the contract to earn the price difference.

However, if his expectation is wrong, he will face the losses arising from such a price risk because he usually does not have any physical positions to offset his loses arising from the futures contract

Direct-hedge versus cross-hedge

A hedge can be a direct-hedge or a cross-hedge. A **direct-hedge** is a hedge in which the hedger uses the same commodity as the commodity that he has in a physical position to hedge against such commodity's spot price change. In other words, in a direct-hedge, the underlying commodities in the spot and futures markets are similar. For example, a ship owner uses the futures price of bunker to hedge against the fluctuation of the spot price of bunker on the spot market.

In contrast, a **cross-hedge** is a hedge in which the hedger uses the futures price of a different but typically related commodity to hedge against his physical position. Typically related commodity" is understood in the sense that the futures price of the typically related commodity must behave the same way as the commodity the hedger has in the physical market. For instance, using the future price of crude oil to hedge against the bunker spot price fluctuation, bunker price and crude oil price is said to be typically/closely related

Direct-hedge is usually more effective than a cross-hedge.

However, a cross-hedge can prove high effectiveness if such a hedge uses the prices of several closely-related commodities.

Hedge ratio

A hedge ratio can be described as a ratio of the asset needed to hedge in the future to the asset the hedger has in physical position. In other words, hedge ratio is the number of future contracts that the hedger has to buy/sell.

Chapter conclusion

To sum up from the above reviews, it is learned that, until today, there is no paper studying the problem of investigating the effectiveness of hedging bunker price using a bunker forwards contract traded at IMAREX and comparing the results obtained with a cross-hedge using different energy futures contracts traded at NYMEX. This is the reason why the topic for this dissertation was triggered.

CHAPTER 3 INFLUENTIAL FACTORS OF THE BUNKER MARKET

"The prices of bunkers is a serious issue as it has added significantly to our cost base both for ship bunker fuel and for all inter-modal costs".

Bunker is the oil-based marine fuel. It is the final product in the refining process after taking out all the higher components such as Gasoline, Aviation spirit, Kerosene and Butane. There are three basic kinds of bunker: the Intermediate Fuel Oil (IFO), the Heavy Fuel Oil (HFO) and the Marine Diesel Oil (MDO). The IFO and HFO bunkers are used for the main engine and are more popular than the MDO bunker which is specially used for auxiliary engine. For IFO bunker, there are two basic grades: IFO380cst (centistokes) and IFO180cst. The distinction between these two grades is the distillate content. The higher the distillate content, the higher energy the fuel has. For example, grade IFO180 has 7- 15% distillate content while IFO380 only has 2-5%. The shipping industry widely uses IFO380 (60% in demand), IFO180 (30% in demand) and the remaining 10% is for MDO. The bunker price totally depends on laws of supply and demand. However, as vessels only take bunker at a limited number of ports around the world (let's say Singapore, Mundra, Fujairah), the bunker price, as a result, reflects the certain situation of bunker supply and demand at a certain port or in a certain region.

After analyzing the bunker market and bunker price in from 2005 to 2016, concentrates on analyzing the determinant factors of the bunker market by examining the supply and demand factors to explore the reasons why bunker price behaves in such ways. Considering the word limitation and, for the demand factors, this chapter firstly focuses on factors that directly impact the bunker price such as the world's economy, international seaborne trade, freight rates, fuel consumption, world tonnage and vessel speed. For supply factors, the factors directly affecting bunker price are examined such as the world oil price, the local demand, the refining capacity, the degree of competition among suppliers and the bunkering methods. Finally, the correlation between bunker price and some of the most determining factors are calculated.

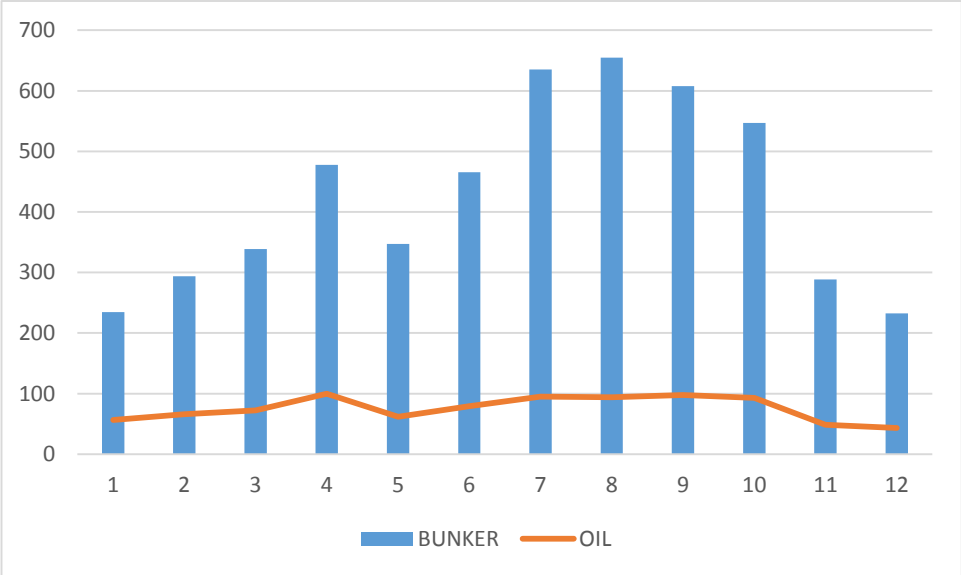
The bunker market

Following the laws of supply and demand, a rise in the demand of bunker will cause an increase in bunker price. The extent of this rise is captured by the price elasticity of demand. The demand of bunker is quite inelastic as bunker is an essential energy for ship propulsion. This finding is confirmed by a high correlation coefficient between bunker price and bunker demand from 2005 to 2016.

Bunkers and the world oil market depend on the supply of fuel oil. The correlation coefficient between crude oil price and bunker price is above 0.95, which differs from the findings of Beenstock &Vergottis (1993) who roughly calculate an elasticity of supply regarding fuel price is around 0.23. The cut-off in supply by OPEC in the bunker market due to the huge demand from China as well as a colder winter in the US explains the affect in the current situation in the bunker market. It depicts the bearing of fuel oil bunker price and fuel oil supply from 2005 to 2016. It explains that supply of fuel oil downs to 1,594

million barrels/day in 2016 from 2,200 million barrels/day in 2005 while bunker price increased from $112/ton in 2005 to $321/ton in 2016 (nearly tripling or 187% increase).

YEAR	BUNKER	OIL
2005	234.5292	56.63
2006	293.6563	66.05
2007	338.7563	72.34
2008	477.7083	99.67
2009	347.325	61.95
2010	465.5917	79.47
2011	635.3167	94.88
2012	655.0292	94.05
2013	607.725	97.97
2014	547.1083	93.19
2015	288.4792	48.67
2016	232.5246	43.29

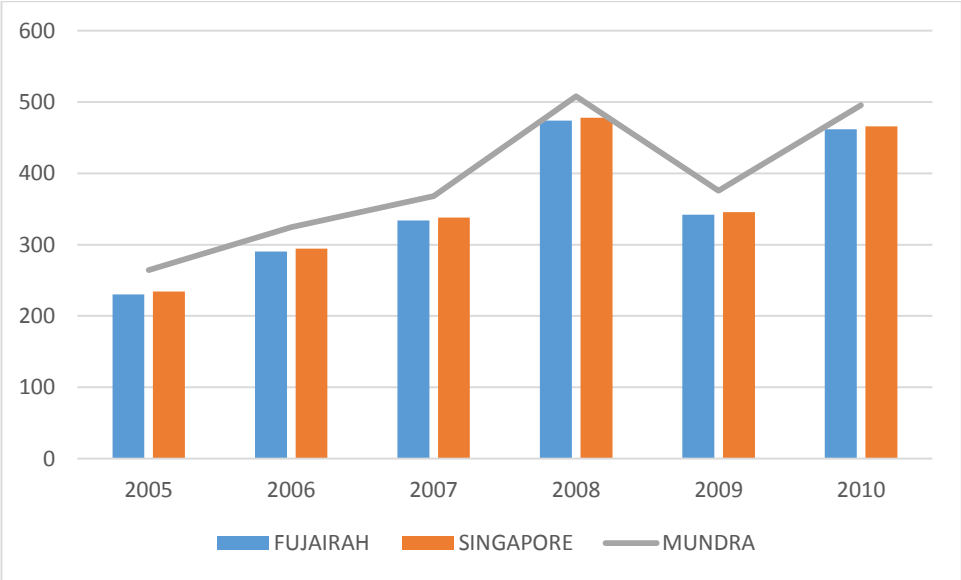


From 2005 to 2016, The bunker market experiences gradual development year by year up to 2008 and a low level in 2009 ,in the year 2011 a sudden increase in the bunker market can be seen up to 2013 it again decreases in the year 2015 and 2016 to a very low level related to the its previous year 2014.

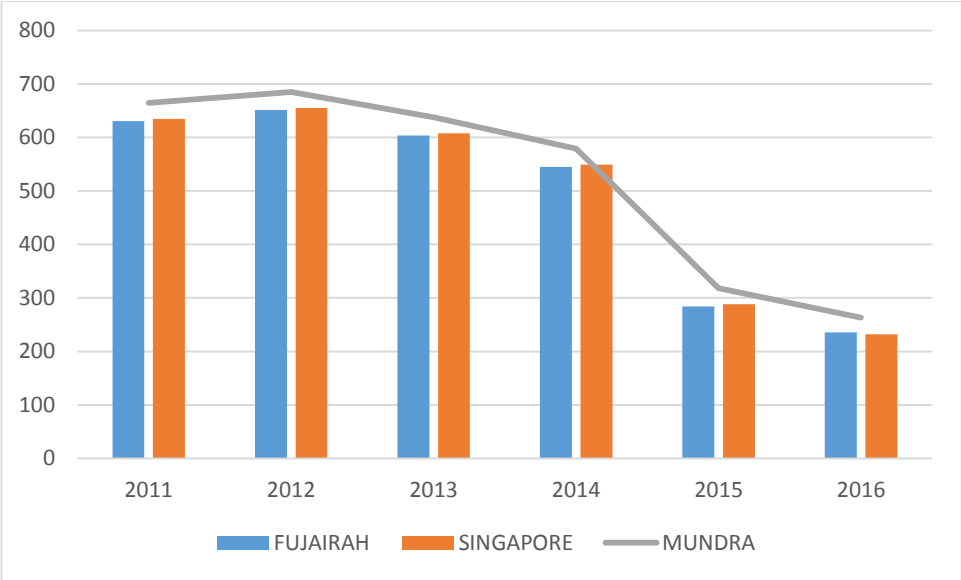
The weekly calculated data of bunker price at mean, standard deviation, Min and Max shows an increase the oil prices in the period 2011-2014 in Table 3.2 due to war broken out due ISIS as supply was limited. The mean is in the range of $93–$94/barrel at three main ports: Mundra, Fujairah and Singapore.

The major importer US started SHALE gas and stops importing oil and also become the major exporter by which supply in world market increased and also to attract buyer the prices got low.
The major importer US started SHALE gas and stops importing oil and also become the major exporter by which supply in world market increased and also to attract buyer the prices got low.

	2005	2006	2007	2008	2009	2010
FUJAIRAH	230.2308	290.2692	333.9519	473.9808	341.75	461.6346
SINGAPORE	234.2308	294.2692	337.9519	477.9808	345.75	465.6346
MUNDRA	264.2308	324.2692	367.9519	507.9808	375.75	495.6346



	2011	2012	2013	2014	2015	2016
FUJAIRAH	630.5385	651.2308	603.8269	545.1154	284.3269	235.7827
SINGAPORE	634.5385	655.2308	607.8269	549.1154	288.3269	232.3288
MUNDRA	664.5385	685.2308	637.8269	579.1154	318.3269	263.0096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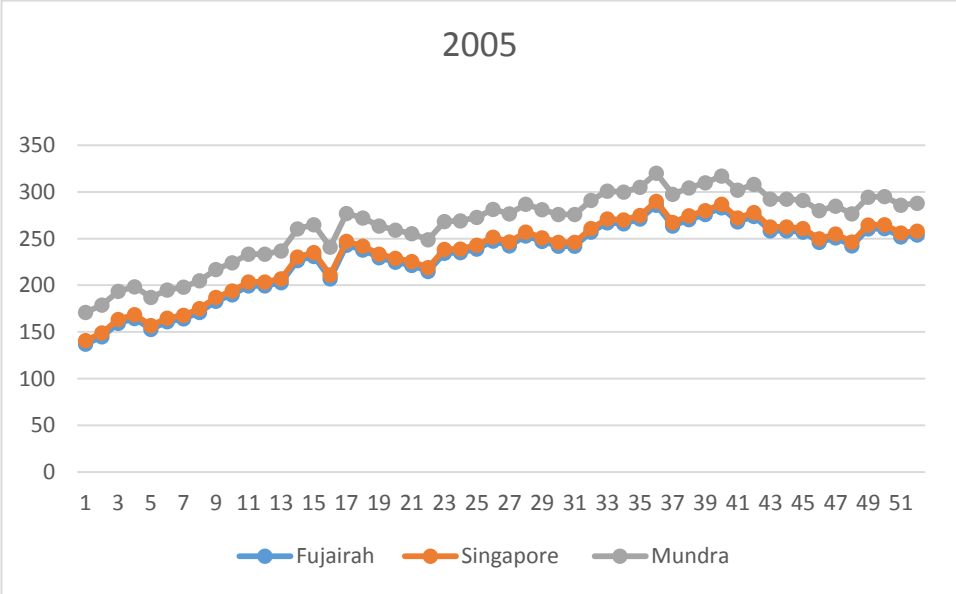
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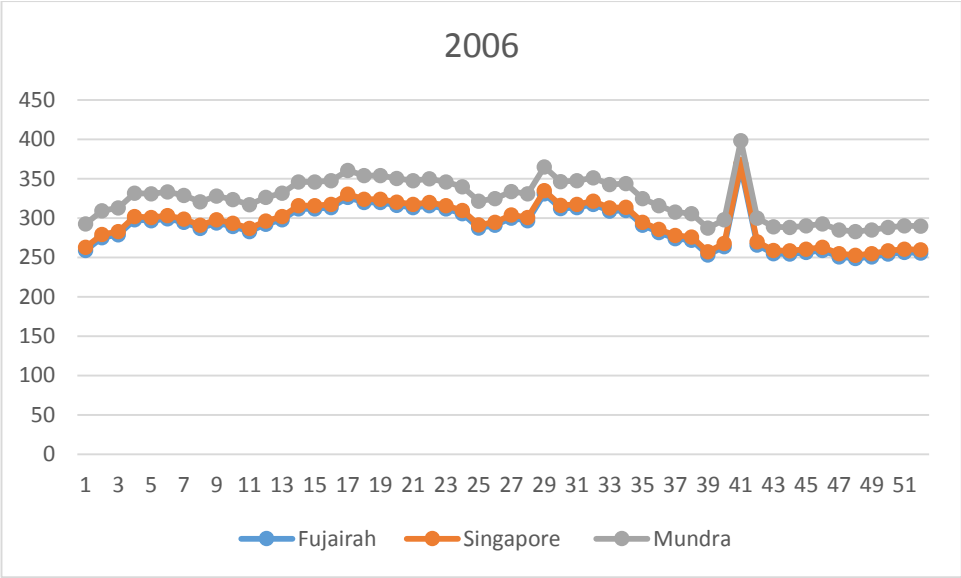
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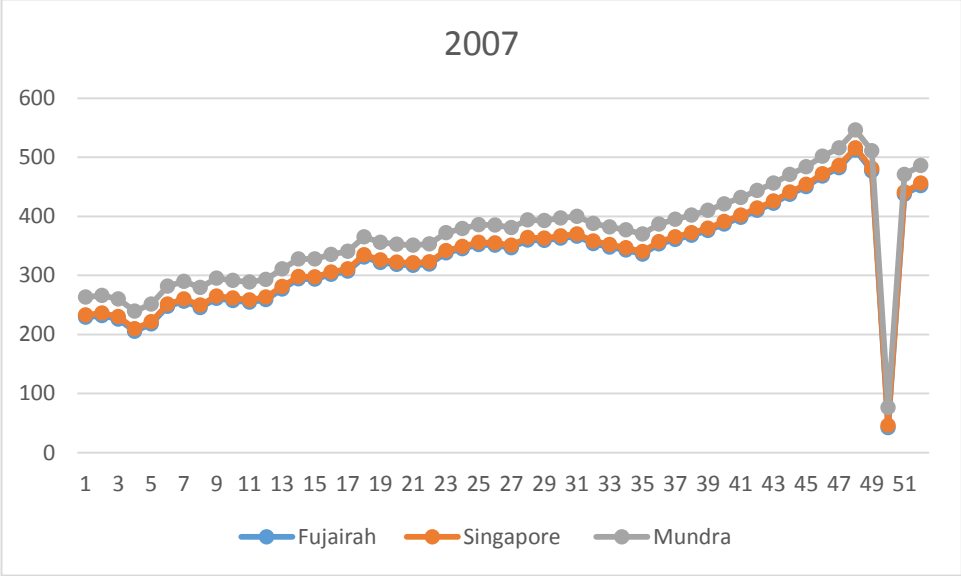
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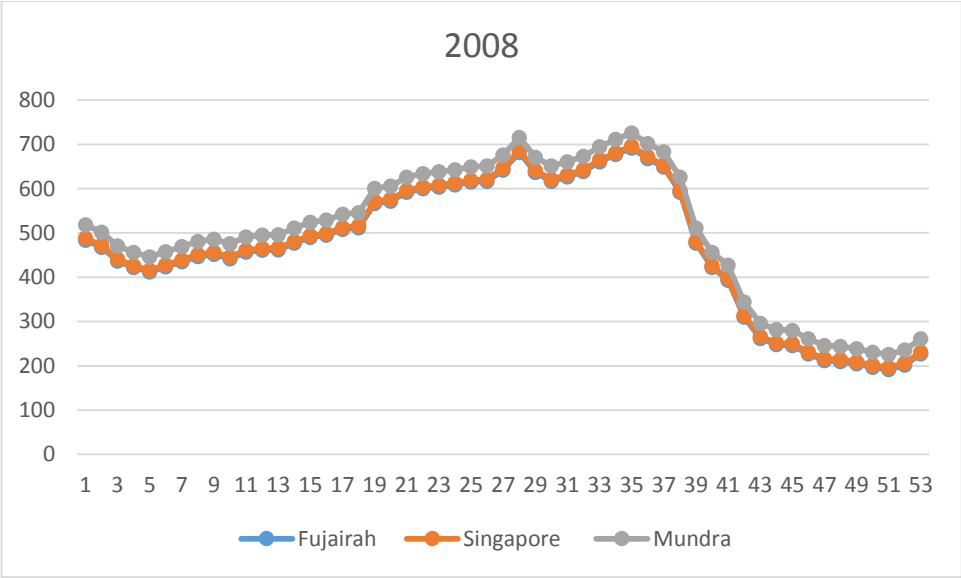
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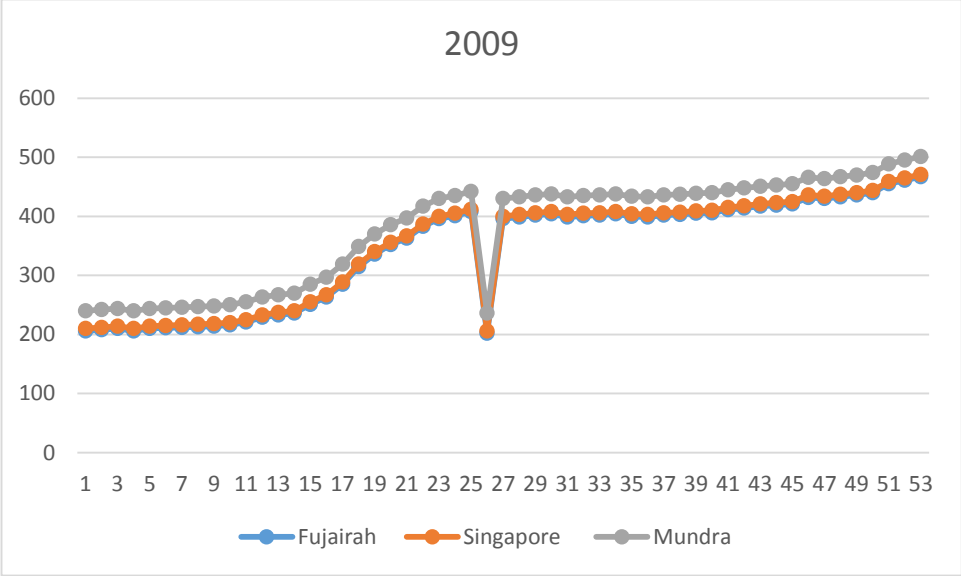
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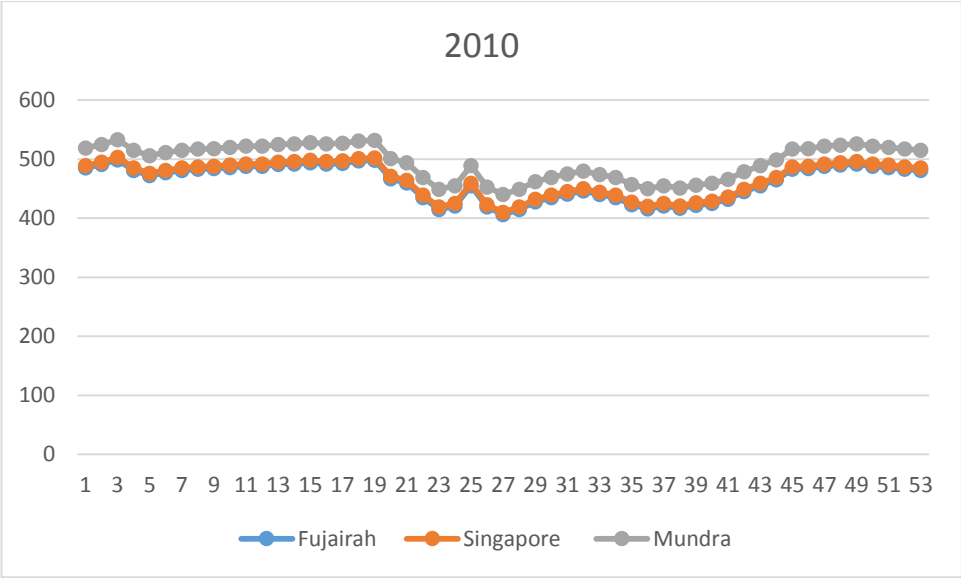
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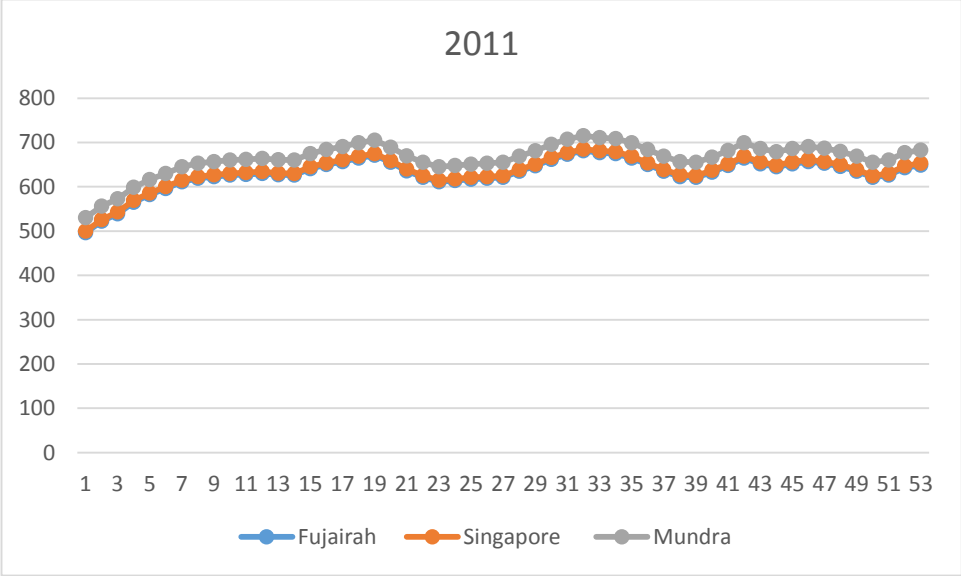
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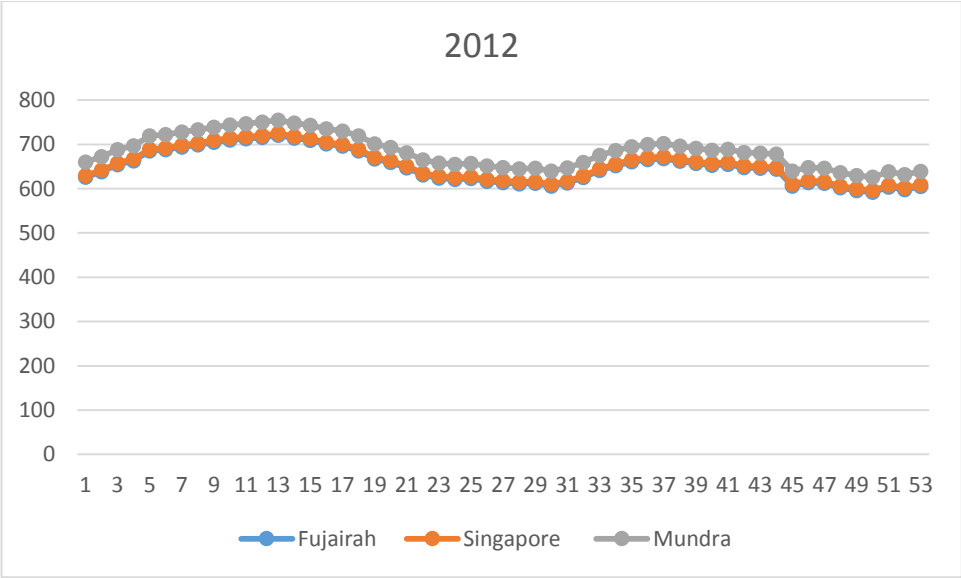
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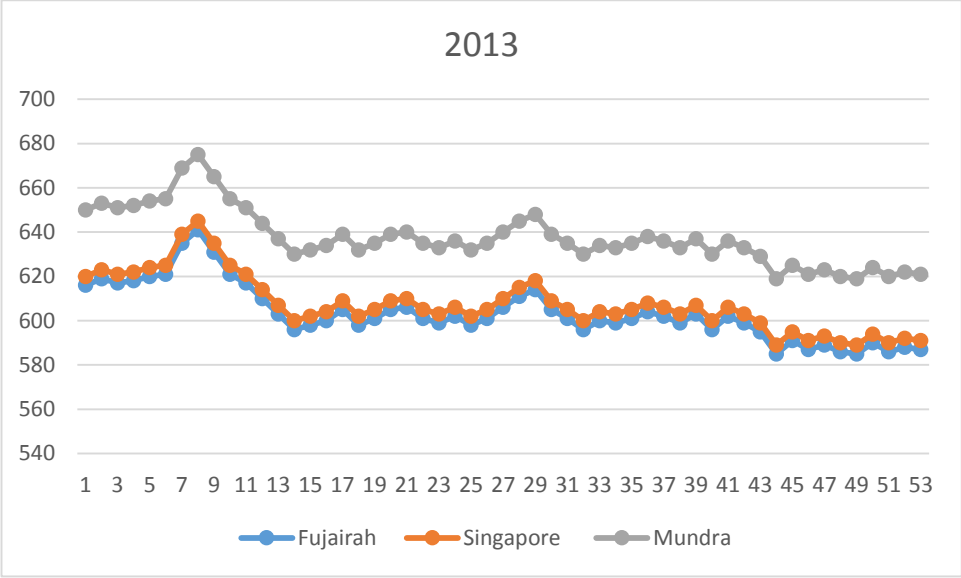
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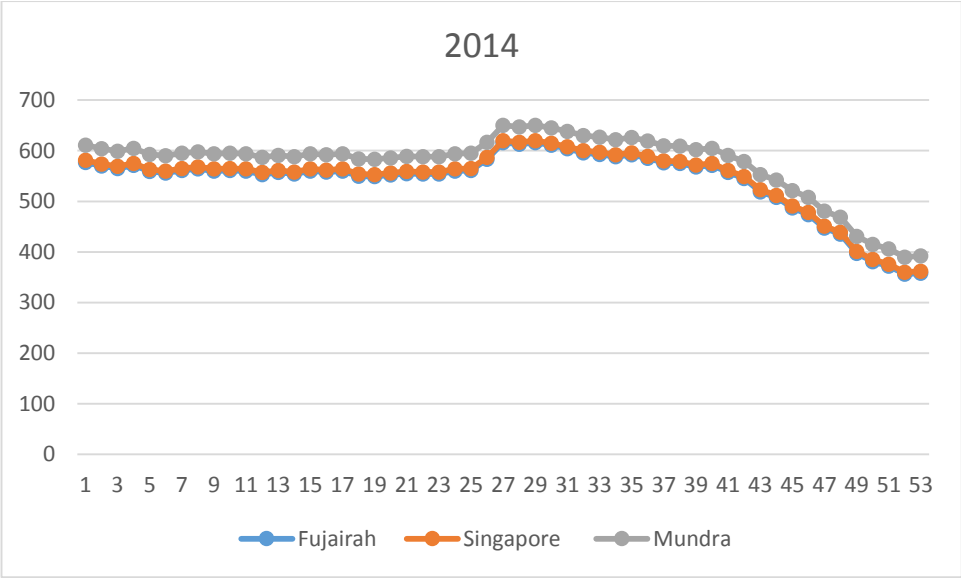
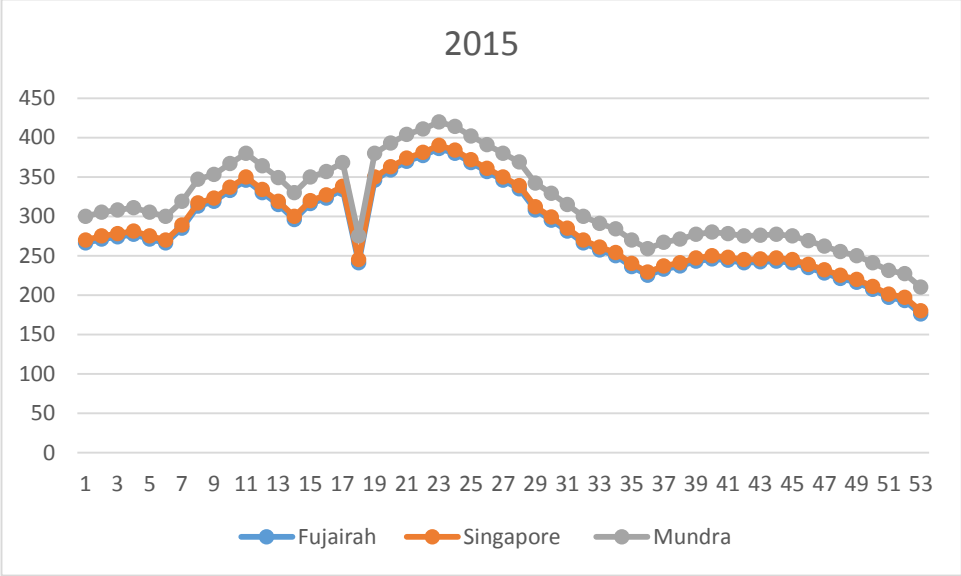




In addition, the standard deviation of bunker price at three main ports in this period is in the range of $4 less in Fujairah then Singapore and Singapore has $30 less than Mundra. The prices in Mundra port are higher because it imports the oil to meet its demand while Fujairah has its own oil production and Singapore has also has its oil production but to meet its high demand it also imports from Fujairah.

The maximum bunker price in 2005-2016 is almost three times higher than the minimum price in 2005-2016. For instance, the maximum bunker price in 2012 was $685.23 (in Mundra) while the minimum price in2005-2016 was only $230.23/barrel (in 2005 at Fujairah). In addition, the bunker price decreases nearly triple in the year 2014 -2015.

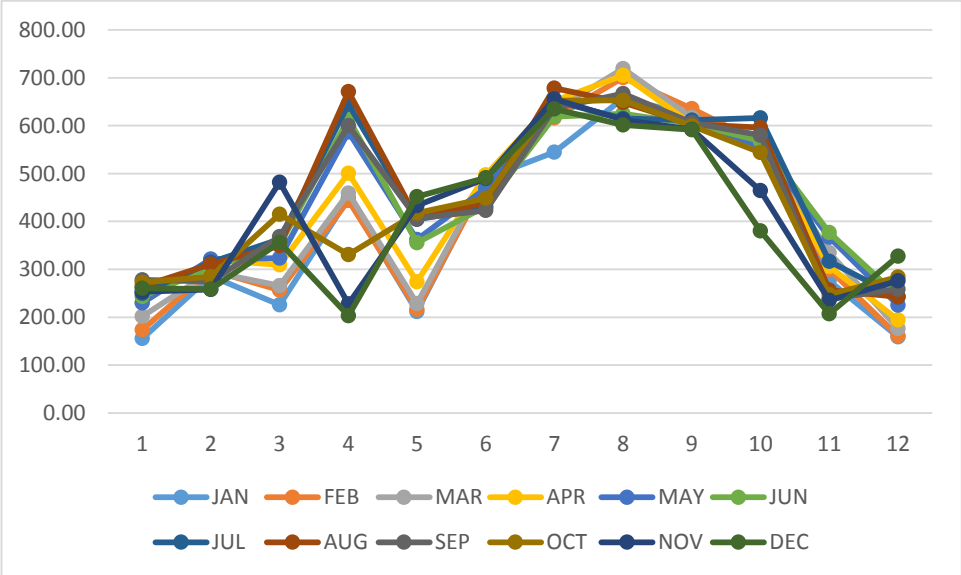
Singapore –Fujairah –Mundra: three major bunker markets

Normally, bunker is sold and bought at every port where ships call for cargo operation or other purposes, all over the world. The graphs show fluctuation in the prices of bunker at three ports. For each individual market, differences in technical requirements (refining capacity, infrastructure and storage capacity) and commercial requirement (sales volume, competitive bunker price) for physical bunkering activities exist.

Singapore

With container traffic ranked at the third place TEU 32.2 Million, Singapore is a leading hub port in Asia and meets the conditions for a highly developed bunker market. Supported by a highly developed fuel oil cargo and a most dense shipping traffic area, Singapore is considered as an Asian benchmark for bunker price In addition, bunker supply in Singapore is supported by a high and stable refining industry as well as by impressive storage capacity.

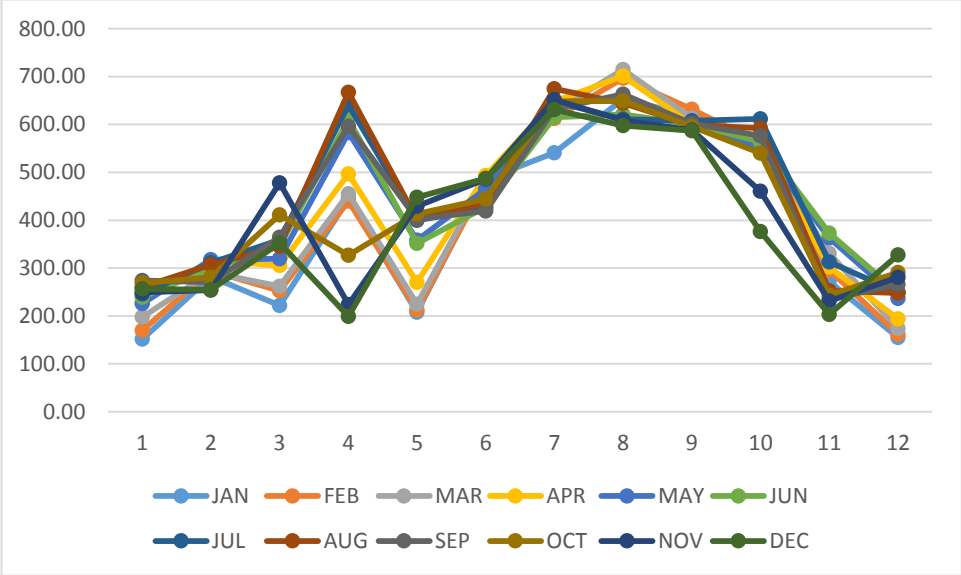
Singapore average monthly bunker prices from 2005-2015



Fujairah

Port of Fujairah is the only multi- purpose port on the Eastern sea board of UAE. The port offers comprehensive facilities for a wide range of requirements such as general and bulk cargo including oil. The port of Fujairah has excellent road connections with in the country and other countries

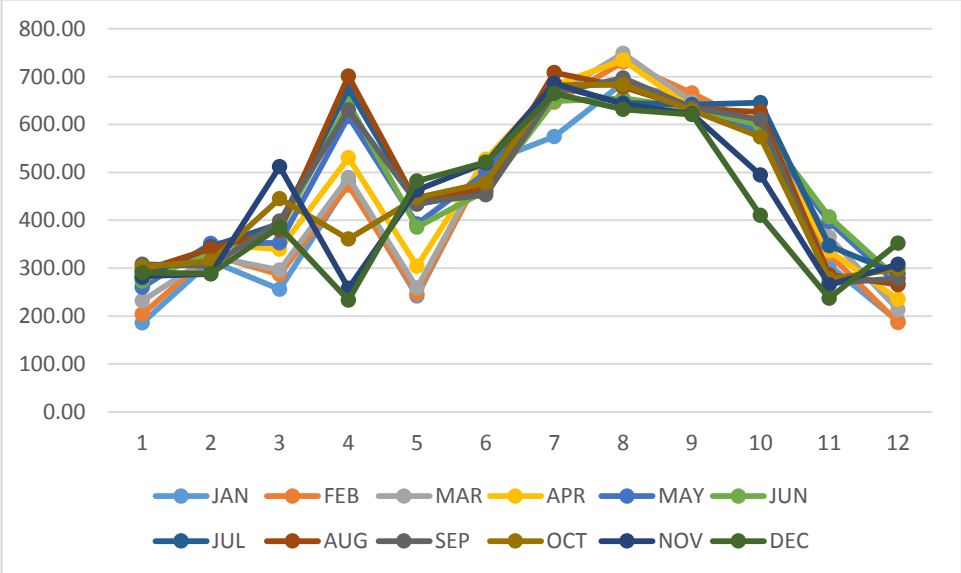
Fujairah average monthly bunker prices from 2005-2015



Mundra

Mundra port is the largest port of India located in the north shore of Gulf of Kutch it is operated by Adani group. In 2013-2014 Mundra port has handled 100 million tonnes of cargo becoming the first Indian port to do so. It offers inland connectivity via rail track road network air port and cross country pipelines.

Mundra average monthly bunker prices from 2005-2015



Supply factors

Oil Market

	OIL PRODUCTION & CONSUMPTION										
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
OIL PRODUCTION	3937.8	3963.9	3951.2	3986.8	3887	3979.1	4012.4	4119.2	4126.6	4228.7	4361.9
OIL CONSUMPTION	3933.9	3977.2	4032.3	4018.1	3948.7	4079.9	4121.6	4168.6	4209.9	4251.6	4331.3

The above chart shows the production and consumption of crude oil in the market from the year 2005 to 2015 it clearly shows the regular increase in the production and consumption of crude oil in the world market.

	WTI OIL	BRENT OIL	BUNKER
2005	56.63	54.57	234.5292
2006	66.05	65.16	293.6563
2007	72.34	72.44	338.7563
2008	99.67	96.94	477.7083
2009	61.95	61.74	347.325
2010	79.47	79.61	465.5917
2011	94.88	111.26	635.3167
2012	94.05	111.63	655.0292
2013	97.97	108.55	607.725
2014	93.19	98.96	547.1083
2015	48.67	52.29	288.4792
2016	43.29	43.67	232.5246

As bunker is the final product in the refining/distillation process of crude oil, factors affecting the crude oil market have a direct impact on the bunker market. For instance when the production of crude oil is more ultimately the prices of the bunker decrease and vice versa.

The above graph shows the prices of crude oil in the market in WIT of USA and Brent of UK we can see that the price difference between the two oil markets is not much between the years 2005 -2010 but from 2011 there is a greater increase in the prices

Period 2010 to 2016: Price difference between WTI and Brent

The Midwest has oversupplied because of all the Canadian import, and the crude oil cannot get down as far as Gulf coast because while there is pipeline capacity in Midwest, there isn't adequate pipeline capacity in Gulf coast for example the opening of two pipelines from Canada (one in April 2010 and one on Feb 2011) seems to contributing to the problem, as is rising North Dakota oil production.

Period 2015-2016: Heavy decrease in prices of oil

Relying of USA on its own oil resources makes it stop importing of oil and on the other hand it started exporting oil in market in less prices which leads to high production and low prices. Historically, the oil price has engaged itself with much fluctuation. After the oil crisis in 1973 which put the bad impact on the oil market, there are other events that have badly influenced oil price, thus consequently the impact on bunker price. The invasion of Kuwait by Iraq in 1990 sent oil prices up to $40/barrel, the Asian financial crisis in late 1998 pulled oil prices down to about $10/barrel. The invasion of Iraq by the USA in 2000 brought oil price up again to $35/barrel. Other events also had an impact on oil prices such as the 9/11 event in 2001 and political conflicts in the Middle East. Also rising of ISIS in the parts of Syria and Iran lead to increase in price rise world.

Changes in bunker level, refining capacities

Bunker supply levels at a certain port depend on the refining capacity of the area of port and the policies made by the countries on import of bunker. Above table and graph show that refining capacities is gradually increases at the big oil refinery area like UAE, India and Singapore have developed in the last ten years and limit the oil products supply as well as bunker supply development.

Other supply factors: bunkering methods, changes in oversea competition, changes in local market

Methods used for bunkering impacts directly on bunker supply use of modern technology in the bunkering leads to cheaper supply price and the conduct operation will be more safer and easier to do. Generally there are two methods of bunkering one is when the ship is at berth bunkering is done directly and the other method is offshore bunkering by using barges. 90% delivering of bunkers all over the world is done by barges as the first bunkering method is expensive as if coming of ships to birth only for bunkering it has to pay port dues. Other factors affecting the bunker supply are the supply conditions in oversea competition as well as in the local market.

Besides the discussed factors, many other factors play on the bunker supply such as competition in the local market, seasonality factor, the effect of unpredictable economic and the natural and political factors.

Calculation of GDP and its role in bunkering and crude oil

GDP is calculated as the sum of consumer spending, business spending, government spending and the total of exports minus imports. In order to factor in inflation and arrive at the real GDP figure, the calculation is as follows:

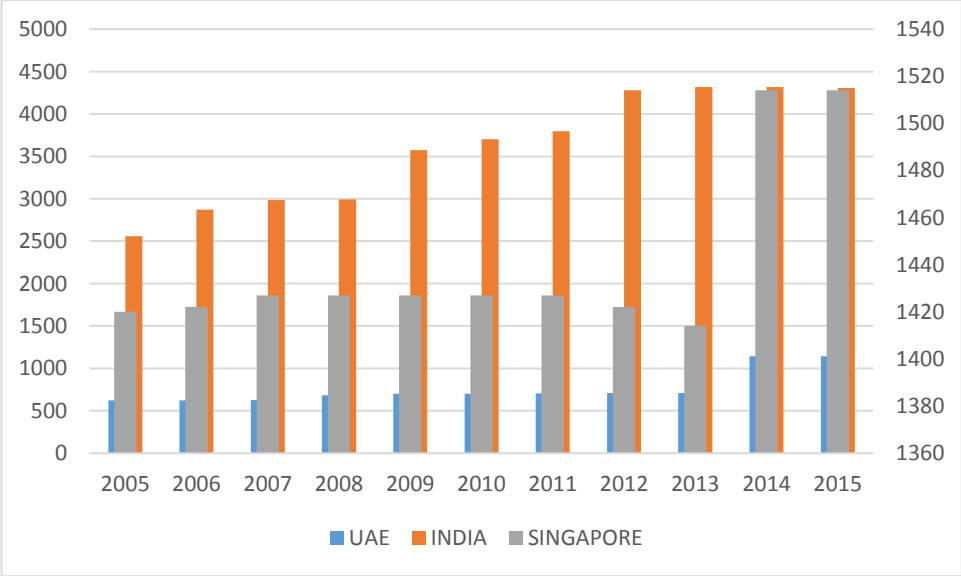
Real GDP = GDP/(1+Inflation since base year)

The base year is designated year updated periodically by the government that is used as a comparison point for economic data such as the GDP. Once real GDP is calculated, then the real GDP growth rate is calculated:

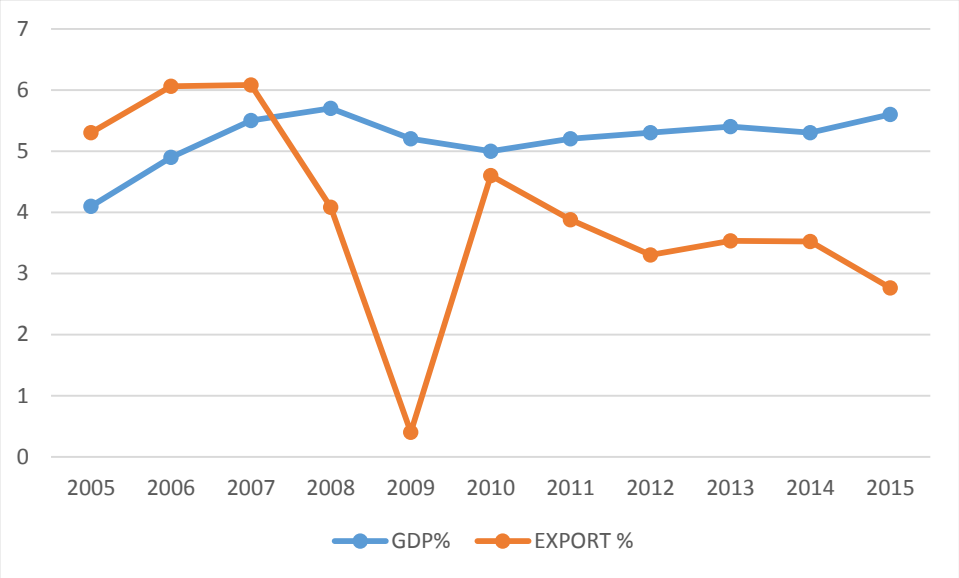
Real GDP growth rate = (Most recent years growth rate GDP) – (The previous year's real GDP/the previous year's real GDP)

The significant contribution of shipping to the country's economy has been confirmed by a survey of the Boston consulting group it accounts for 13.5 billion euros on an annual basis. The graph shows an increase in %age of GDP at world level year by year which is a good sign of development but still many countries are very low in GDP and the growth rate is contributed by some of the rich countries.

REFINERY GROWTH IN THOUSAND BARREL PER DAY											
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**
UAE	620	620	625	680	700	700	705	710	710	1143	**1143**
INDIA	2558	2872	2983	2992	3574	3703	3795	4279	4319	4319	**4307**
SINGAPORE	1420	1422	1427	1427	1427	1427	1427	1422	1414	1514	**1514**

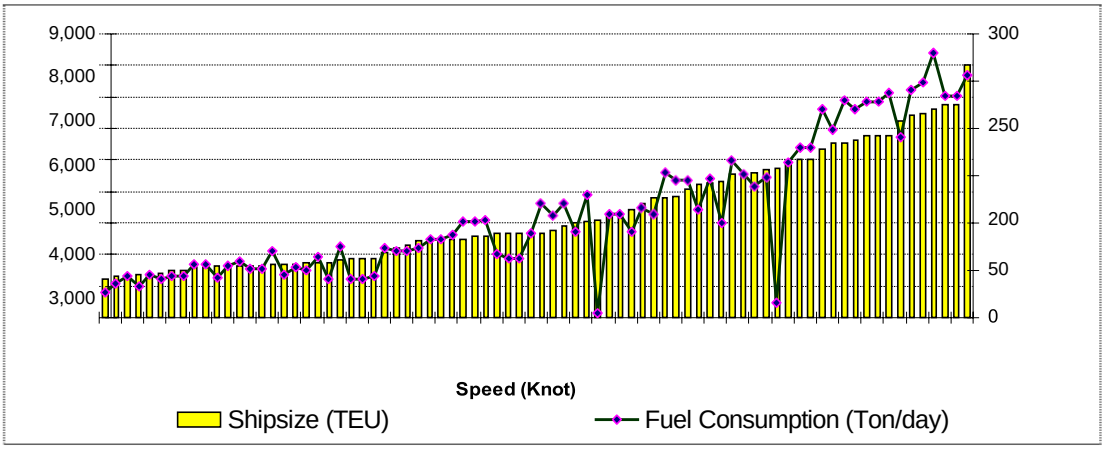


GROWTH OF COUNTRIES GSP & EXPORT IN %											
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
GDP%	4.1	4.9	5.5	5.7	5.2	5	5.2	5.3	5.4	5.3	5.6
EXPORT %	5.3	6.06	6.08	4.08	0.4	4.6	3.88	3.3	3.53	3.52	2.76



YR: 2005- 2008			Fujairah	Singapore	Mundra
Mean			331.61	335.61	365.61
ST. Deviation			127.4125	127.4125	127.4125
MAX			692	696	726
MIN			142	146	176

YR: 2009- 2012			Fujairah	Singapore	Mundra
Mean			521.84	525.84	555.84
ST. Deviation			137.6215	137.6215	137.6215
MAX			721	725	755
MIN			202	206	236



YR: 2013- 2016			Fujairah	Singapore	Mundra
Mean			416.64	418.81	448.97
ST. Deviation			167.1213	168.9833	168.6402
MAX			641	645	675
MIN			146	150	180

SINGAPORE MONTHY PRICES

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
JAN	155.80	285.70	226.00	448.60	212.00	489.60	544.80	657.20	622.00	572.40	275.80	159.00
FEB	173.75	297.88	256.50	443.50	216.50	485.25	616.25	700.50	636.00	564.25	299.75	160.95
MAR	202.00	294.75	266.00	459.50	228.75	492.25	631.75	719.00	616.75	561.75	335.00	176.44
APR	230.88	320.00	309.40	500.40	274.00	497.60	651.80	705.00	603.40	560.40	306.00	194.03
MAY	229.80	321.20	323.13	586.75	362.50	469.00	649.75	655.00	607.25	556.50	367.00	225.38
JUN	243.00	303.13	350.50	615.25	355.75	431.50	619.25	625.25	604.00	568.50	376.75	244.03
JUL	250.13	314.80	363.00	645.00	404.00	429.00	651.60	615.20	611.40	616.00	317.00	242.53
AUG	264.60	310.88	349.25	671.25	405.75	440.00	678.50	648.75	603.00	596.25	256.25	242.22
SEP	278.00	274.38	368.50	600.50	406.25	423.00	636.25	667.25	606.00	580.00	238.50	258.63
OCT	272.40	284.80	414.80	331.00	417.40	448.40	652.60	653.20	599.40	544.00	247.20	283.85
NOV	253.13	257.88	482.00	227.75	433.00	490.25	656.00	612.50	592.25	464.75	235.25	275.88
DEC	260.88	258.50	356.00	203.00	452.00	491.25	635.25	601.50	591.25	380.50	207.25	327.38

MUNDRA MONTHLY PRICES

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
JAN	185.80	315.70	256.00	478.60	242.00	519.60	574.80	687.20	652.00	602.40	305.80	189.00
FEB	203.75	327.88	286.50	473.50	246.50	515.25	646.25	730.50	666.00	594.25	329.75	186.00
MAR	232.00	324.75	296.00	489.50	258.75	522.25	661.75	749.00	646.75	591.75	365.00	213.00
APR	260.88	350.00	339.40	530.40	304.00	527.60	681.80	735.00	633.40	590.40	336.00	234.95
MAY	259.80	351.20	353.13	616.75	392.50	499.00	679.75	685.00	637.25	586.50	397.00	265.28
JUN	273.00	333.13	380.50	645.25	385.75	461.50	649.25	655.25	634.00	598.50	406.75	276.88
JUL	280.13	344.80	393.00	675.00	434.00	459.00	681.60	645.20	641.40	646.00	347.00	288.25
AUG	294.60	340.88	379.25	701.25	435.75	470.00	708.50	678.75	633.00	626.25	286.25	266.06
SEP	308.00	304.38	398.50	630.50	436.25	453.00	666.25	697.25	636.00	610.00	268.50	278.45
OCT	302.40	314.80	444.80	361.00	447.40	478.40	682.60	683.20	629.40	574.00	277.20	298.35
NOV	283.13	287.88	512.00	257.75	463.00	520.25	686.00	642.50	622.25	494.75	265.25	307.84
DEC	290.88	288.50	386.00	233.00	482.00	521.25	665.25	631.50	621.25	410.50	237.25	352.03

FUJAIRAH MONTHLY PRICES

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
JAN	151.80	281.70	222.00	444.60	208.00	485.60	540.80	653.20	618.00	568.40	271.80	155.00
FEB	169.75	293.88	252.50	439.50	212.50	481.25	612.25	696.50	632.00	560.25	295.75	161.40
MAR	198.00	290.75	262.00	455.50	224.75	488.25	627.75	715.00	612.75	557.75	331.00	173.90
APR	226.88	316.00	305.40	496.40	270.00	493.60	647.80	701.00	599.40	556.40	302.00	193.80
MAY	225.80	317.20	319.13	582.75	358.50	465.00	645.75	651.00	603.25	552.50	363.00	236.64
JUN	239.00	299.13	346.50	611.25	351.75	427.50	615.25	621.25	600.00	564.50	372.75	248.60
JUL	246.13	310.80	359.00	641.00	400.00	425.00	647.60	611.20	607.40	612.00	313.00	248.95
AUG	260.60	306.88	345.25	667.25	401.75	436.00	674.50	644.75	599.00	592.25	252.25	247.98
SEP	274.00	270.38	364.50	596.50	402.25	419.00	632.25	663.25	602.00	576.00	234.50	265.80
OCT	268.40	280.80	410.80	327.00	413.40	444.40	648.60	649.20	595.40	540.00	243.20	290.38
NOV	249.13	253.88	478.00	223.75	429.00	486.25	652.00	608.50	588.25	460.75	231.25	280.36
	256.88	254.50	352.00	199.00	448.00	487.25	631.25	597.50	587.25	376.50	203.25	327.65

Singapore		
YEAR	WTI OIL	Bunker oil
2005	56.63	234.2307692
2006	66.05	294.2692308
2007	72.34	337.9519231
2008	99.67	477.9807692
2009	61.95	345.75
2010	79.47	465.6346154
2011	94.88	634.5384615
2012	94.05	655.2307692
2013	97.97	607.8269231
2014	93.19	549.1153846
2015	48.67	288.3269231
2016	43.29	232.3288462

Fujairah		
YEAR	WTI OIL	Bunker oil
2005	56.63	230.2307692
2006	66.05	290.2692308
2007	72.34	333.9519231
2008	99.67	473.9807692
2009	61.95	341.75
2010	79.47	461.6346154
2011	94.88	630.5384615
2012	94.05	651.2307692
2013	97.97	603.8269231
2014	93.19	545.1153846
2015	48.67	284.3269231
2016	43.29	235.7826923

Mundra		
YEAR	WTI OIL	Bunker oil
2005	56.63	264.2308
2006	66.05	324.2692
2007	72.34	367.9519
2008	99.67	507.9808
2009	61.95	375.75
2010	79.47	495.6346
2011	94.88	664.5385
2012	94.05	685.2308
2013	97.97	637.8269
2014	93.19	579.1154

2015	48.67	318.3269
2016	43.29	263.0096

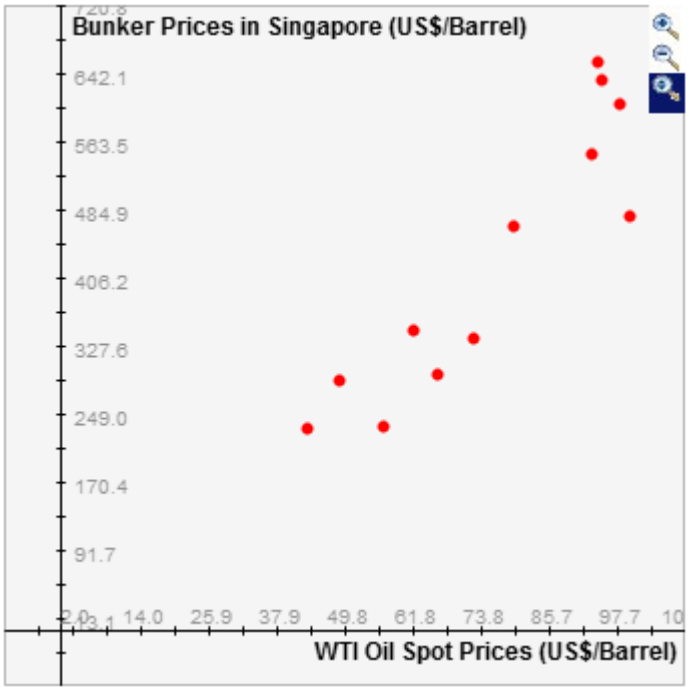
Singapore		
YEAR	BRENT OIL	Bunker oil
2005	54.57	234.2307692
2006	65.16	294.2692308
2007	72.44	337.9519231
2008	96.94	477.9807692
2009	61.74	345.75
2010	79.61	465.6346154
2011	111.26	634.5384615
2012	111.63	655.2307692
2013	108.55	607.8269231
2014	98.96	549.1153846
2015	52.29	288.3269231
2016	43.67	232.3288462

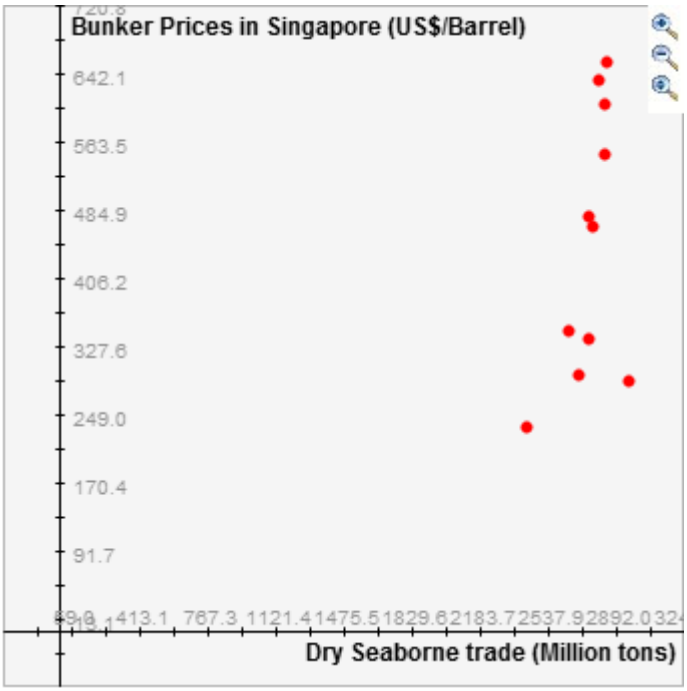
Fujairah		
YEAR	BRENT OIL	Bunker oil
2005	54.57	230.2307692
2006	65.16	290.2692308
2007	72.44	333.9519231
2008	96.94	473.9807692
2009	61.74	341.75
2010	79.61	461.6346154
2011	111.26	630.5384615
2012	111.63	651.2307692
2013	108.55	603.8269231
2014	98.96	545.1153846
2015	52.29	284.3269231
2016	43.67	235.7826923

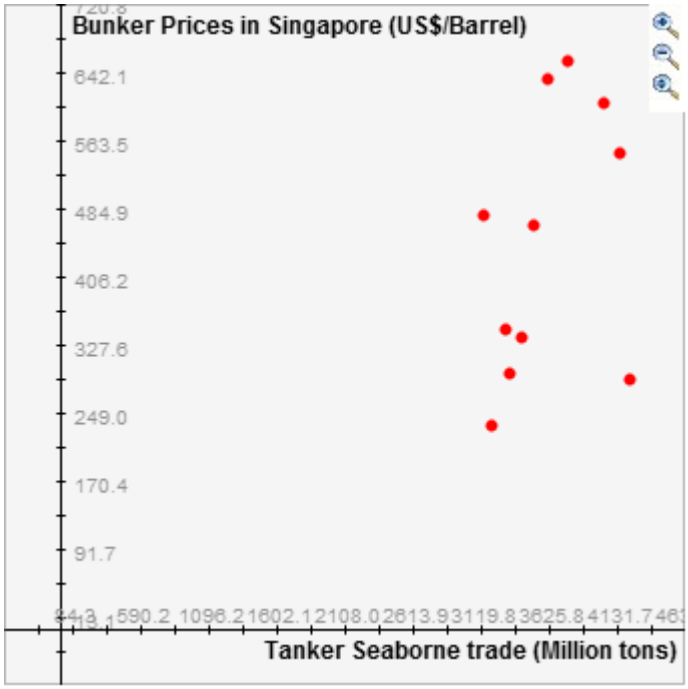
Mundra		
YEAR	BRENT OIL	Bunker oil
2005	54.57	264.2308
2006	65.16	324.2692
2007	72.44	367.9519
2008	96.94	507.9808
2009	61.74	375.75
2010	79.61	495.6346
2011	111.26	664.5385
2012	111.63	685.2308
2013	108.55	637.8269

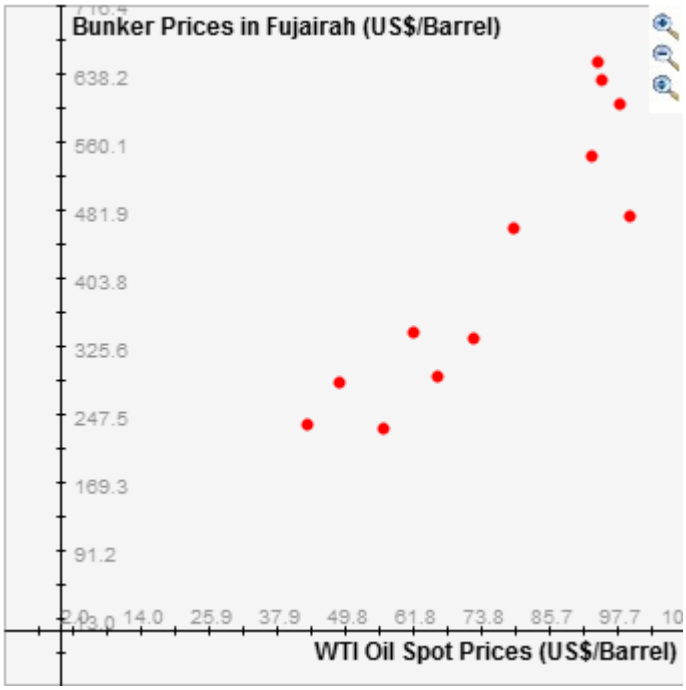
2014	98.96	579.1154
2015	52.29	318.3269
2016	43.67	263.0096

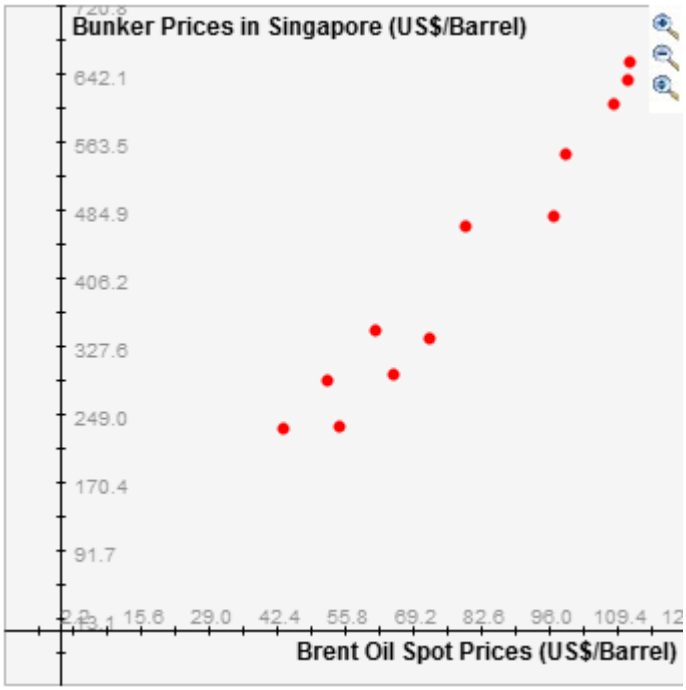
Singapore		
YEAR	**Dry Seaborn trade**	**Bunker oil**
2005	2422	234.2307692
2006	2698	294.2692308
2007	2747	337.9519231
2008	2742	477.9807692
2009	2642	345.75
2010	2772	465.6346154
2011	2794	634.5384615
2012	2841	655.2307692
2013	2829	607.8269231
2014	2825	549.1153846
2015	2951	288.3269231
Singapore		
YEAR	**tanker**	**Bunker oil**
2005	3188	234.2307692
2006	3334	294.2692308
2007	3422	337.9519231
2008	3131	477.9807692
2009	3302	345.75
2010	3505	465.6346154
2011	3614	634.5384615
2012	3762	655.2307692
2013	4033	607.8269231
2014	4150	549.1153846
2015	4216	288.3269231

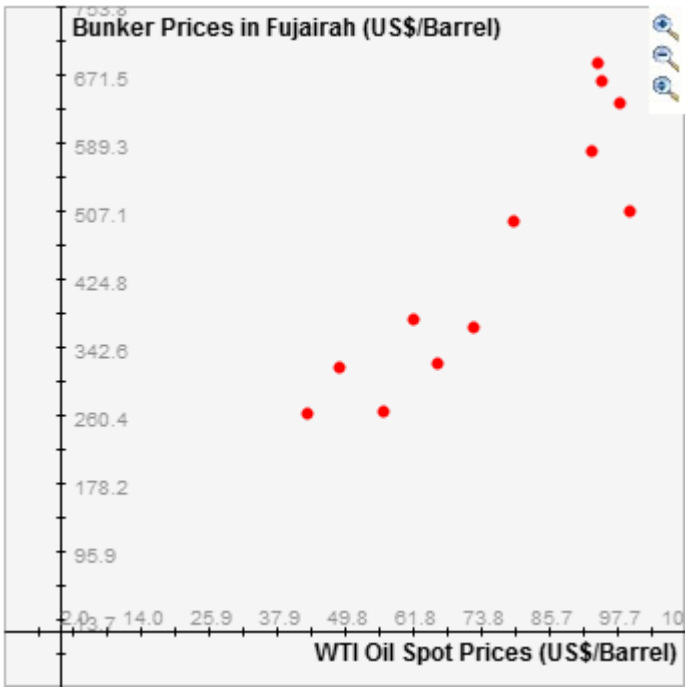

Bunker Prices in Singapore (US$/Barrel)
642.1
563.5
484.9
406.2
327.6
249.0
170.4
91.7
14.0
25.9
37.9
49.8
61.8
73.8
85.7
97.7
WTI Oil Spot Prices (US$/Barrel)

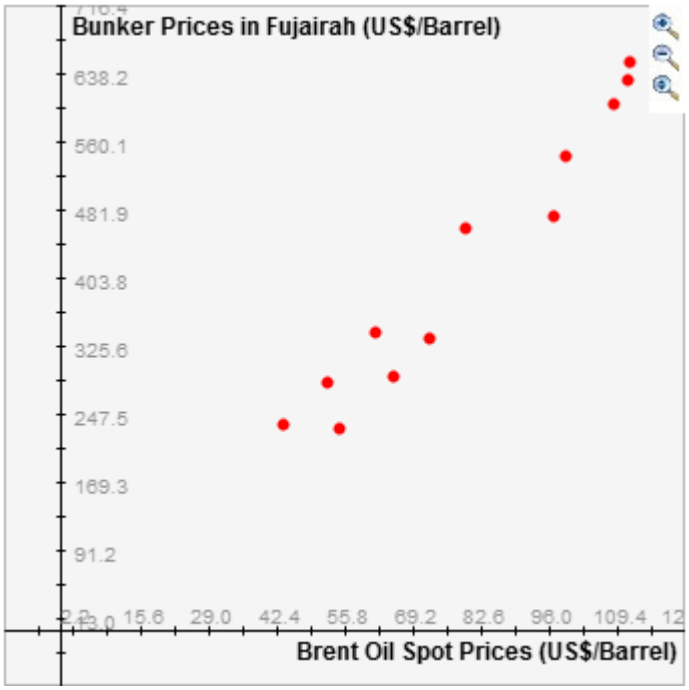

Bunker Prices in Singapore (US$/Barrel)
642.1
563.5
484.9
406.2
327.6
249.0
170.4
91.7
413.1
767.3
1121.4
1475.5
1829.6
2183.7
2537.9
2892.0
Dry Seaborne trade (Million tons)

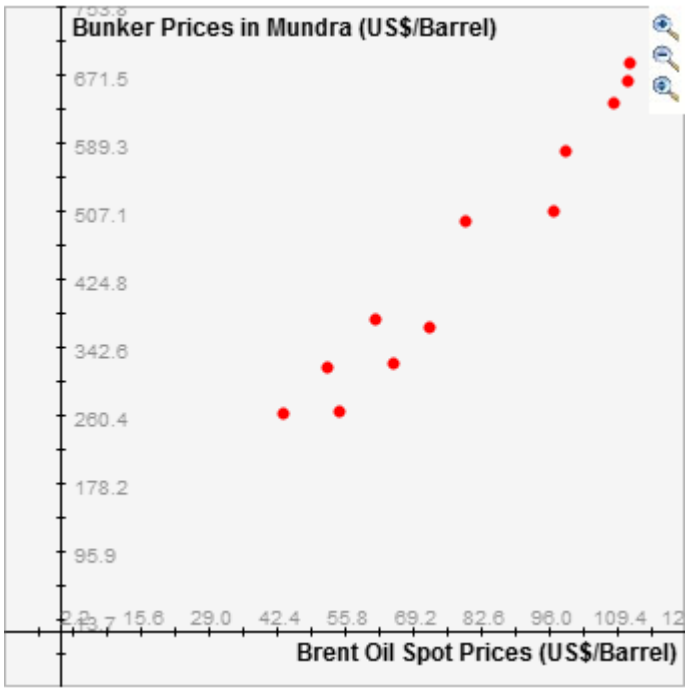

Bunker Prices in Singapore (US$/Barrel)
642.1
563.5
484.9
406.2
327.6
249.0
170.4
91.7
590.2
1096.2
1602.1
2108.0
2613.9
3119.8
3625.8
4131.7
Tanker Seaborne trade (Million tons)


Bunker Prices in Fujairah (US$/Barrel)
638.2
560.1
481.9
403.8
325.6
247.5
169.3
91.2
14.0
25.9
37.9
49.8
61.8
73.8
85.7
97.7
WTI Oil Spot Prices (US$/Barrel)


Bunker Prices in Singapore (US$/Barrel)
642.1
563.5
484.9
406.2
327.6
249.0
170.4
91.7
15.6
29.0
42.4
55.8
69.2
82.6
96.0
109.4
Brent Oil Spot Prices (US$/Barrel)


Bunker Prices in Fujairah (US$/Barrel)
671.5
589.3
507.1
424.8
342.6
260.4
178.2
95.9
14.0
25.9
37.9
49.8
61.8
73.8
85.7
97.7
WTI Oil Spot Prices (US$/Barrel)


Bunker Prices in Fujairah (US$/Barrel)
638.2
560.1
481.9
403.8
325.6
247.5
169.3
91.2
15.6
29.0
42.4
55.8
69.2
82.6
96.0
109.4
Brent Oil Spot Prices (US$/Barrel)


Bunker Prices in Mundra (US$/Barrel)
671.5
589.3
507.1
424.8
342.6
260.4
178.2
95.9
15.6
29.0
42.4
55.8
69.2
82.6
96.0
109.4
Brent Oil Spot Prices (US$/Barrel)

CHAPTER 4 INTRODUCTION TO BUNKER HEDGING INSTRUMENTS

Bunker price is regulated by the laws of supply and demand. Factors affecting the supply and demand of bunker engage themselves in the risk, factors of oil price and freight rate (demand). Because the nature is very risky oil price and freight rate, which leads to highly volatile nature of bunker price as presented. Using instruments like of financial hedging in mitigating risk arising from the fluctuation of price is not new in the commodity and financial markets. This concept, of financial instruments for hedging against bunker price is new has developed recently in the shipping industry.

Mid–1980s, ship owners and ship operators, who confronted with huge risk in the industry, realized that such instruments like Futures, Options, Forward and Swaps contracts in the commodity and financial market can be applied to reduce risk in the shipping industry. Which resulted, in 1988, the first bunker futures contract at Singapore Futures Exchange. Eleven years later, in 1999, similar contract was introduced at the London-based International Petroleum Exchange because of the limited trading volume, both contracts failed to bring and attract players and were then eventually withdrawn from the market. Bunker future contracts in Singapore Future Exchange stopped at the beginning of 1990s while the one in London IPE finished only 6 months after coming into operation.

The reasons for such failures, because of the nature of bunker market where physical bunkers are taking place in different ports around the world while bunker futures contracts was for the delivery of bunker in specific locations. Futures price of bunker do not behave in the same manner as the physical bunker prices at different ports around the world. This, as a result, reduces the effectiveness of hedging through futures contracts.

In absence of exchange-based futures contract for hedging bunker price, researchers have put effort to search for the alternative cross-hedge instruments. A study undertaken proved that the most typically related commodity that could serve a cross-hedge purpose for bunker is the energy (crude oil, gas oil and heating oil). Energy futures contracts is the best alternative for bunker futures contract in hedging against bunker price.

This chapter introduce the hedging instruments that can be used to hedge against bunker price fluctuations. Some examples are also shown for understanding of hedging function of such instruments.

Bunker hedging instruments

Without exchange-based future contract, in order to reduce losses arising from the fluctuation of bunker price, ship owners, ship operators and other related parties can use cross-hedge with an energy futures contract, a bunker forward contract, a bunker swaps agreement or a bunker options agreement to hedge against the bunker price fluctuations.

Hedging bunker price using a cross-hedge with energy futures contract

A future contract is a highly standardized instrument agreed between a seller and a buyer to deliver a certain quantity of the underlying asset at an agreed price and at a certain time in the future. All futures contract must be traded on an exchange-based market place with strict rules and regulations under the management of a clearing-house. The size of a future contract is standardized by a number of units such as lots and each lot is equal to. In a futures contract, a range of delivery dates is usually specified and the settlement is exercised on a daily-basis and is usually closed out prior to the contract maturity.

The reason to hedge against bunker price fluctuation using a cross-hedge with energy futures contract is that there is no exchange-based market for bunker futures trading. We can use energy futures contract for a cross-hedge for bunker price. The function of a cross-hedge through energy futures contract as a hedging instrument for bunker price is complicated. However, to see how hedging bunker functioning through a cross-hedge with energy futures contract, we may consider the following simple example. Suppose that on 15 June 2007, a ship owner fixes a contract to carry cargo from Singapore to Fujairah, the voyage will be carried out one month later (on 15 July 2007). The voyage will need about 5,000tons of IFO380 to be loaded at Mundra on 15 July 2007. At present, there is energy futures contract (let's say Brent crude oil) traded at NYMEX with one lot = 1,000 barrels, standard contract is equal to one lot10. On 15 June, IFO380 price is $360.5/ton11, total bunker cost for 6,000 tons is 5,000 x 359 = $1795000. The ship owner is worried that the bunker price will increase on 15 July and he decides to hedge against such an increase by buying Brent crude futures contracts. Futures price of Brent crude on 15 June is $70/barrel, thus the ship owner has to buy $1795000 / (1,000x$70) = 25 future contracts.

As the ship owner expected, on 15 July the bunker price increases by $364/ton at Mundra, thus on the spot market the ship owner has to load bunker to carry out the voyage and face a loss of 5,000 x ($364 -$359) = $25,000. However, on the future market, Brent crude increases by $74/barrel, thus the ship owner decides to sell 31 contracts and has a gain of 25x1,000 x ($74- $70) = $100,000. As a result, a portfolio of spot and futures market brings the ship owner a gain of $100,000 -$25,000 = $75,000 instead of a loss of $25,000 if he would have stayed unhedged.

However, if the bunker price decreases by $357/ton on 15 July instead of an increase as the ship owner expects, then on the spot market he has a saving of 5,000 x ($359 - $355) = $20,000. Meanwhile, on the futures market, Brent crude decreases by $68/barrel, thus the ship owner sells 31 contracts and faces a loss of 25 x 1,000 x ($70-$68) = $50,000. Consequently, a portfolio of spot and futures market results in a loss of only $50,000 - $25,000 = $25,000 instead of a saving of $50,000 if he had not hedge with the futures contract.

There may be other scenarios derived from the changes of bunker price and the changes of energy futures contract price thus resulting in the loss or gain of the ship owner. Such an amount of loss or gain then depends firstly on the forecast of bunker price (increase or decrease) and secondly on the rate of change between the bunker price and energy futures contract price.

Cross-hedge with energy futures prices, the highest hedging effectiveness for hedging bunker price.

Hedging with a bunker forward contract

In the absence of a future contract for hedging bunker and the low effectiveness of hedging bunker through a cross-hedge with energy futures contract bunker risk management could also be carried out with over-the-counter (OTC) bunker agreement which was developed in the 1990s in an effort for the alternative of future contracts. Nowadays, many financial institutions and commodity trading houses such as Morgan Stanley Investment Bank, O.W. Bunker Malta bunker trader offer such OTC bunker derivative products. Forward Bunker contract is one of such OTC agreements.

A Forward Bunker Agreement is defined as an OTC agreement between a bunker seller and a bunker buyer to exchange a specified quantity of bunker of certain quality, at an agreed price and at a certain place and time of delivery in the future.

Hedging under the Forward Bunker contract, the whole gain or loss of the ship owner or ship operators from bunker price fluctuation could be realized at the end of the life (duration) of the contract. As a result, it allows the participants to "forward" the price before contract maturity.

Forward	Futures
Private contract between two parties	Traded on an exchange-base
Contract is not standardized	Contract is standardized
One delivery date is specified	Allows a range of delivery date
Settled at the end of contract	Settled daily
Physical delivery or final cash settlement	Contract is usually closed out
Usually take place	Prior to maturity
Parties accept some credit risks	Virtually no credit risk

The function of the Forward Bunker contract as a hedging instrument can be explained in the following example. Suppose that, on 15 June 2007, a ship owner fixed a voyage charter to carry cargo from Singapore to Mundra, such a voyage will need 2,000 tons of IFO380 (to be loaded at Singapore) and will be carried out on 15 July 2007. On 15 June 2007, spot price of IFO380 at Singapore is USD 359/ton13. So if this price does not change until 15 July 2007, the voyage will cost him USD 2,000*359 = USD 718,000.

When looking at the increasing bunker price trend provided by Bunkerworld on 15 June 2007 the owner expects that the bunker price will increase and will be higher than USD 359/ton on 15 July 2007.

In order to hedge himself against such a price increase, he decides to buy a Forward Bunker contract for such an amount of bunker to be delivered on 15 July 2007. The Forward bunker price is agreed at, for example, USD 368/ton at Singapore. By doing so, the owner has fixed the bunker cost for the voyage at USD 2,000*368 = USD 736,000.

Table 4.1 Two possible outcomes of owner's forward hedging bunker contract

On 15 June 2007	
SPOT MARKET	**FORWARD MARKET**
Bunker price at Singapore: $ 360.5/ton Bunker cost = $8,000*360.5 = $ 2,884,000	Action: buys forward contract Bunker price agreed at: $365/ton
First scenario: bunker price increase	**Second scenario**: bunker price decrease
On 15 July 2007 **(Spot market)**	
Bunker price at Singapore: $ 368/ton Bunker cost = $ 8,000*368 = $ 2,944,000 Owner loses = $ 2,944,000 – $ 2,884,000	Bunker price at Singapore: $ 357/ton Bunker cost = $ 8,000*357 = $ 2,856,000 Owner gains = $ 2,884,000 – $2,856,000
On 15 July 2007 **(Forward market)**	
Action: sells forward contract Bunker price at Singapore:$ 368/ton Agreed forward price: $ 365/ton Owner gains = $ 8,000*(368 –365) = $ 24,000	Action: sells forward contract Bunker price at Singapore: $357/ton Forward price: $ 365/ton Owner loses = $ 8,000*(365 – 357)
Portfolio of spot and forward positions	
Net loss in portfolio of $ 36,000 instead of $ 60,000 loss	Net loss in portfolio of $ 36,000 instead of $ 28,000 gain

Source: Summarized by author from the example

On 15 July 2007, suppose the owner decides on a final cash settlement with the forward contract provider and the bunker price is now at USD 368/ton at Singapore (higher than owner's expectation). To close the forward contract, on 15 July 2007, the owner sells his forward contract to the forward contract provider and gains USD 2,000*(368-359) = USD 18,000 (he could also require a physical delivery).

However, on 15 July 2007, to fulfill his voyage charter to carry cargo from Singapore to Mundra, the owner has to pay for the bunker cost at USD 2,000*368 = USD 736,000 instead of only USD 2,000*359 = USD 718,000 that he would have paid on 15 June 2007. So, on the spot market he lost USD 736,000 – USD 718,000 = USD 60,000. As a result, on both the spot and forward markets the owner only losses USD 60,000 – USD 24,000 = USD 36,000 (if he had not hedged himself by buying the forward contract, he will lose USD 60,000).

Second scenario, the bunker price will decrease and be lower than on 15 June 2007

If on 15 July 2007, the bunker price is only at USD 357/ton, because the forward contract price was at USD 365/ton, so to close the forward contract, the owner then sells his forward contract to the forward contract provider at the price of USD 357/ton and losses USD 2,000*(365-357) = USD 16,000.

However, on 15 July 2007, to fulfill his voyage charter to carry cargo from Singapore to Mundra, the owner only has to pay for the bunker cost USD 2,000*357 = USD 714,000 instead of only USD 2,000*359 = USD 718,000 that he would have paid on 15 June 2007. So, on the spot market he gains USD 2,884,000 – USD 2,856,000 = USD 28,000. As a result, on both the spot and forward
markets the owner only losses USD 64,000 – USD 28,000 = USD 36,000 (if he had not bought the forward contract, he would have gained USD 28,000).

The conclusion from the two scenarios is that if the bunker price increase is higher than forward-agreed price, the gain in the forward contract (USD 24,000) will cover a part of the losses in the spot position (USD 60,000). If the bunker price decreases to a level lower than the spot price, the savings in the spot position will cover a part of the losses in the forward contract.

Hedging with a bunker swaps agreement

Bunker swap is an OTC agreement between two bunker suppliers or bunker purchasers to exchange their cash flows arising from the fluctuation of future bunker prices by locking in an agreed fixed bunker price. In this agreement, the parties agree the dates when the cash flows are to be paid as well as the way they use to calculate such cash flows. The calculation thus considers the future value of an interest rate, an exchange rate, or other market variables.

A simple bunker swap (or plain vanilla) is an agreement in which a floating price for bunker (usually the market price) is exchanged for a fixed price for bunker (usually the price that is agreed to fix by the swap participants) over one or various specified periods and for a certain volume of bunker per period gives a clearer explanation for a swap agreement.

Swap transactions between bunker supplier/bunker buyer A and bunker buyer/bunker supplier B

According to Hull, a bunker swap contract can be considered as a portfolio of bunker forward contracts or a bunker forward contract can be viewed as a simple example of a bunker swap. In the bunker forward contract, the exchange of cash flows is taken place just only on one future date while a bunker swaps could lead to cash flows exchange taking place on several future dates gives a comparison between the characteristics of a forward contract and a swap contract.

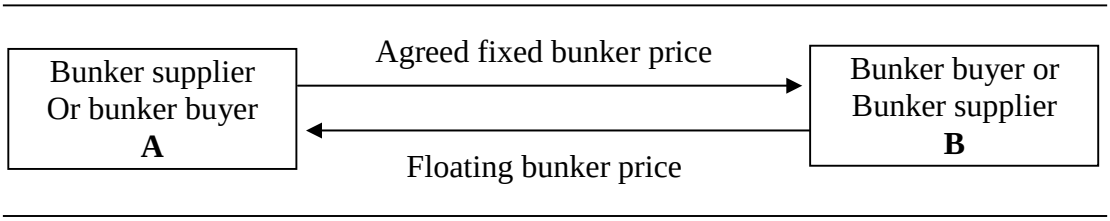


Table 4.2 Comparison of Forward and Swap contracts

Forward contract	Swap contract
Single forward contract	Portfolio of forward
contracts One future delivery date is specified	Several future delivery
dates Settled at the end of contract	Settled by period
Physical delivery or final cash settlement	No physical delivery, only final
cash Parties accept some credit risks	High credit risk

Swap bunker contract is the difference between the floating price of bunker and the fixed. Price of bunker on the due dates. The outcome of the hedging with such a swap bunker contract is the portfolio (combination) of the result of such a swap bunker contract and the result on the transactions of physical market.

To see how a bunker swap contract functions as a hedging instrument, consider the following example. For example in April 2007, an owner has fixed a COA (Contract of Affreightment) to carry coal from Newcastle (one of the biggest Australia ports operating coal) to Kobe port (one of the big ports in Japan dealing with coal) at a fixed freight rate per ton agreed in COA. The contract is for 12 months, each shipment per month, from April 2007 to March 2008. To carry single voyage from Newcastle to Kobe, the owner estimates that he needs approximately 1,000 tons of bunker fuel/voyage to be loaded at Newcastle. Suppose the spot bunker price in April 2007 at Newcastle is $350/MT. It is expected that the bunker price will increase in next 12 months, he decides to hedge himself against such a price increase by entering into a swap contract with a Financial Institution or other Bunker Suppliers who provide such an OTC swap contract. Because he estimates that each voyage will need about 1,000 MT of bunker, he decides to buy a swap contract with 12 lots (for 12 voyages) and each lot is 1,000 MT of bunker at the end of each month. The swap price is agreed at $360/MT against the floating bunker prices prevailing at the last business day of each month in Newcastle between the owner and the swap provider. At the end of March 2008, it appears that from April 2007 to March 2008, the spot bunker price in April 2007 at Newcastle is $350/MT. Worried that the bunker price will increase in the next 12 months, he decides to hedge himself against such a price increase by entering into a swap contract with a Financial Institution or other Bunker Suppliers who provide such an OTC swap contract. Because he estimates that each voyage will need about 1,000 MT of bunker, he decides to buy a swap contract with 12 lots (for 12 voyages) and each lot is 1,000 MT of bunker at the end of each month. The swap price is agreed at $360/MT against the floating bunker prices prevailing at the last business day of each month in Newcastle between the owner and the swap provider. At the end of March 2008, it appears that from April 2007 to March 2008, the spot.

As a result, the settlement of the swap contract is like that: for such floating (spot) bunker prices which are higher than $360/MT (swap fixed bunker price), the swap provider has to pay the difference between floating price and the swap price to the owner. Contrarily, for such floating (spot) bunker prices which are lower than $360/MT, the owner has to pay the difference to the swap provider.

Hedging with a bunker options agreement

There are two types of option. A *call option which* gives the holder the right to buy (or not to buy) an asset by a specific date at an agreed price. A *put option which* gives the holder the right to sell (or not to sell) an asset by a specific date at an agreed price. The specific date in an option is the *expiration date* or *maturity date*. The agreed price is the *exercise price* or a *strike price*. Consequently, a bunker option contract gives the holder the right to buy (or not to buy) or the right to sell (or not to sell) a certain amount of bunker, by a specific date and at a strike price.

An option can be traded either on an exchange-based market or on over-the-counter market. There is still no exchange based market for trading bunker except over-the-counter market. As a result, for those who want to hedge their bunker with an option contract on the exchange-based market, have to search for an alternative through a cross-hedging with the energy options?

Options have two styles: the *American option* –the option that can be exercised at any time up to the maturity date and the *European option* –the option that can only be exercised on the maturity date. Option contracts are usually settled in cash terms and the contract holder has to pay an amount of money (or premium) to buy the option.

The function of hedging against the bunker price fluctuation with an option contract can be explained as: when the ship owners or ship operators expect that the bunker price will increase in the coming time, they then go for a *call option* contract to buy a certain amount of bunker, by a certain maturity date in future and at a certain price (and he pays a certain amount of money as premium, usually 3-4% of the contract value). When the maturity date comes, if the spot bunker price is higher than the strike price, he then exercises the call option (the right to buy) and gains the difference between spot price and strike price. In contrast, if the spot price appears to be lower than the strike price, he can ignore the option and loses the premium.
To see how an option functions as a hedging instrument, consider the following example. Suppose that, on 15 September, 2007, an owner fixes a voyage charter with a charterer to carry cargo from the Mundra to Fujairah, such voyage needs 4,000 tons of bunker fuel and will be carried out on 15 November, 2007.

Suppose that, on 15 Sep, 2007, the spot bunker price is $344/ton. Expecting that such a bunker price will increase on 15 Nov, 2007, to hedge for such an increase, the owner then buys an option contract for 4,000 tons of bunker, at the strike price of $350/ton and will expire on 15 Nov, 2007. The option contract costs him $2/ton (total premium = $2*4,000 = $8,000).

On 15 Nov, 2007, suppose that the spot bunker price increases to $354/ton. So this spot price is higher than the strike price. The owner then exercises the option contract to buy 4,000 tons of bunker at the strike price ($350/ton) and gets the payoff of $4,000*(354-350) –$8,000 (premium) = $8,000 from the option contract provider.

However, on the spot market, he has to buy 4,000 tons of bunker to exercise the intended voyage at the spot price of $354/ton and faces a loss of $4,000*(354-344) = $40,000. A portfolio of spot and option only results in a loss of $40,000 –$8,000 = $32,000 instead of the whole $40,000 if he had not used the option.

In the opposite scenario, instead of increasing to $354/ton the spot bunker price decreases to $340/ton. Thus, on the spot market, the owner gains (savings) an amount of $4,000*(344-340) =$16,000. On the option market, because the spot price is lower than the strike price, the owner then does not exercise the option contract and losses the premium of $8,000. As a result, a portfolio of spot and option brings a saving of $16,000 –$8,000 =$8,000 in total bunker cost for the owner.

To sum up, it is understood from the above explanations that hedging bunker price fluctuations with an option contract could result in a saving in the total bunker cost for ship owners. The amount of saving then depends on the negotiation of strike price.

CHAPTER 5 INVESTIGATING THE EFFECTIVENESS OF HEDGING AGAINST BUNKER PRICE FLUCTUATION

Analysis of methodologies for estimating the hedge ratio and hedging effectiveness

There are many methods to estimate hedge ratio. Johnson states that if we denote S_1 and F_1 the spot price and future price at time t_1, and S_2 and F_2 the spot and future price at time t_2, then price changes from time t_1 to t_2 the gain (loss) of hedger will be $[(S_2 - S_1) - (F_2 - F_1)]$. The hedge is perfectly effective only if $[(S_2 - S_1) - (F_2 - F_1)]$ is equal to zero.

Ederington and Ferguson & Leistikow use OLS (Ordinary Least Squares) linear regression to regress futures price changes on spot price changes to obtain the hedging effectiveness. The linear regression equation is:

$$S_{t+1} - S_t = \alpha + \beta * (F_{t+1} - F_t) + \varepsilon \quad (5.1)$$

where S_t and F_t denote spot and future price at time t; S_{t+1} and F_{t+1} denote spot and futures price at time $t+1$, α denotes a constant term (a residual or the intercept), β denotes the slope of coefficient or the minimum hedge ratio and ε is an allowance for error. Yang & Allen estimate the hedge ratio of the Australian futures markets by using a bivariate Vector Autoregression (VAR) model where the spot and futures prices are modeled under the bivariate VAR equations:

$$\Delta S_t = \alpha_s + \sum_{i=1}^{k} \beta_{si} \Delta F_{t-i} + \sum_{i=1}^{k} \theta_{si} \Delta F_{t-i} + \varepsilon_{st} \quad (5.2)$$

$$\Delta F_t = \alpha_f + \sum_{i=1}^{k} \beta_{fi} \Delta S_{t-i} + \sum_{i=1}^{k} \theta_{fi} \Delta F_{t-i} + \varepsilon_{ft} \quad (5.3)$$

In equations and ΔS_t and ΔF_t represent changes in the logarithm of spot and futures prices. α_s and α_f denote the constant term (a residual or intercept); β_s, β_f , θ_s and θ_f is the parameters; ε_{st} and ε_{ft} are independently distributed random vectors. If ∂_{ss} and ∂_{ff} denote vector auto regression of futures prices and spot futures prices, then ∂_{ss} = Var(ε_{st}), ∂_{ff} = Var(ε_{ft}) and Cov(ε_{st}, ε_{ft}) = ∂_{sf}, the minimum variance hedge ratio h^* (risk minimizing hedge ratio) can be obtained by the equation $h^* = \frac{\partial_{sf}}{\partial_{ff}}$

Kavussanos & Nomikos used VECM model in ARCH family introduced by Engle to investigate the hedge effectiveness of the BIFFEX contracts where the future price and spot are presented by vector $X_t = (S_t F_t)'$.

$$\Delta X_t = \mu + \sum_{i=1}^{p-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-1} + \varepsilon_t;\ \varepsilon_t = \begin{pmatrix} \varepsilon_{S,t} \\ \varepsilon_{F,t} \end{pmatrix} \Big| \Omega_{t-1} \sim IN(0,\ H_t)$$

$$H_t = \begin{pmatrix} h_{SS,t} & h_{SF,t} \\ h_{SF,t} & h_{FF,t} \end{pmatrix} = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B$$

In equations and, Γi and Π are 2 x 2 coefficient matrices calculating long-run and short run adjustment of system to changes in X_t and ε_t is vector of residuals $(\varepsilon_{S,t}\varepsilon_{F,t})'$, Ht is time-varying covariance matrix, C is 2 x 2 lower triangular matrix and A and B is 2 x 2 diagonal coefficient matrices.

The models of ARCH family especially the VAR and VECM model are complicated and require deep knowledge of not only mathematics but also of the time-series structure data. In this dissertation the OLS regression model is used to estimate the hedge ratio and hedging effectiveness of hedging against fluctuations in the bunker price by testing (1): a **direct-hedge** with bunker forward prices traded at IMAREX and (2): a **cross-hedge** with WTI crude oil futures prices (contract 1, 2, 3 and 4) and Heating oil futures prices (contract 1, 2, 3 and 4) traded at NYMEX.

Analyzing the using of the OLS regression model

The linear regression equation (5.1) estimates the constant term α (a residual or an intercept) and the slope of coefficient β (hedge ratio). It also generates certain statistics associated with the regression including *t-statistics* and the *R*-squared.

Equation (5.1) can be reduced as $\Delta S_t = \alpha + \beta * \Delta F_t + \varepsilon; \varepsilon \sim (0, \sigma^2)$ (5.7)

Where $\Delta S_t = (S_{t+1} - S_t)$ and $\Delta F_t = (F_{t+1} - F_t)$ represent the changes in the logarithms[18] of spot and futures prices respectively. *T-statistics* measures the significance of the estimated parameters including the constant term α and the slope β, in other words, it measures the degree of confidence in the accuracy of α and β. The slope β is expected to be equal to or as close to 1 as possible and *t-statistics* of β is expected to be statistically significant (*t-statistics*> 2) while the of the constant term α is expected not to be significant (or *t-statistics* < 2).

R-squared (often written R^2) is the coefficient of determination between ΔS_t and ΔF_t and the R^2 value measures the effectiveness of the hedge performance. The higher the R^2 the greater the hedge effectiveness is.

Investigating hedging bunker effectiveness using the OLS regression model

Using a direct-hedge with bunker forward contracts traded at IMAREX

IMAREX started in 2000 with the objective of becoming the largest international marketplace of shipping derivatives, IMAREX (International Maritime Exchange) has become first authorized and regulated marketplace to trade and clear such derivatives in world (IMAREX, 2007c). IMAREX went public on April 4, 2005 when it listed on the Oslo Stock Exchange. Launching bunker fuel oil derivatives since December 5, 2005, IMAREX is now the only global market place offering electronic trading of bunker fuel oil derivatives with straight-through clearing (IMAREX, 2007a)

IMAREX provides bunker fuel contracts for all its trading and clearing members. The main bunker futures contracts are Fujairah 3.5% sulphur barges FOB; Northwestern Europe (NWE) 1.0% sulphur barges FOB; Singapore IFO180cst FOB; Singapore IFO380cst FOB; and Fujairah IFO380cst FOB. Prices are quoted for USD per metric ton and contract durations of 1, 6, 12 month, 6 quarters and 2 calendar years. The standardized contract is decided by 'lot', one lot = 1,000MT, the minimum contract

is 0.1 lot, maximum contract is 999 lots (990,000MT) (IMAREX, 2007a). After nearly 1.5 years of trading, bunker futures trading including bunker forward and bunker swap at IMAREX developed very fast both in volume and value.

Data collection

Bunker spot prices at the three main markets Singapore, Fujairah and Mundra obtained on daily basis from IMAREX, Singapore port office. Bunker at Singapore and Fujairah is IFO380cst, bunker at Mundra is FO3.5% sulphur & reported in US dollar per metric ton. The data range of Singapore and Fujairah is from January 2005 to January 2016 (994 observations); for Mundra is from January 2005 to 2007 (497 observations).

For the forward prices, bunker 1-month forward and 12-month forward prices for Singapore are IFO380cst and are obtained on a daily basis and also at the same period of spot prices (399 observations). Forward prices at Fujairah are for FO3.5% sulphur and also reported on for the same period as spot prices (374 observations).

Estimating the hedge ratio and hedging effectiveness

Application of OLS regression model, Jarque and Bera tests for normal distribution of spot and forward prices and Philips & Perron tests for the stationarity of bunker prices series and spot forward are deployed to test the fitness of the data ranges with OLS regression operations. Standard deviation and Mean methods are applied to know fluctuation of forward prices and bunker spot.

Test of stationarity (Unit root test)

Results of Philips & Perron (PP) tests and Jarque and Bera (J-B) tests determines the prices of bunker at three markets i.e. Singapore, Fujairah and Mundra are normally distributed.

Table 5.2 Descriptive statistics of Bunker Prices

	N	Average	Std. Dev.	Skew	Median	Normal Distributed
	(1)	(2)	(3)	(4)	(5)	(6)
Singapore	**497**	386.956	145.498	0.29	363	NO
Fujairah	**497**	383.725	144.767	0.29	359	NO
Mundra	**497**	417.037	145.337	0.29	393	NO

Standard deviations in *column 3* imply that spot prices are more volatile. For instance, the Singapore prices are more volatile than Fujairah and Mundra (145.498 versus 145.337 at Mundra and 145.498 versus 144.767 at Fujairah market). Results of Philips & Perron tests indicate that bunker prices are non-stationary.

Estimate the hedge ratio and hedging effectiveness

We tries to estimate the hedge ratio (β), the hedging effectiveness (R^2) as well as the constant term α and standard error ε by using the OLS regression model to regress the changes on the logarithm of spot bunker prices at Singapore, Fujairah and Mundra and the changes on the logarithm of different bunker prices.

If we define the 1st difference of logarithms of Singapore, it can be seen that the *t-statistics* satisfies both conditions: the in- significance of constant term α and the significance of the hedge ratio β for the Singapore and Fujairah markets. For the Mundra market, *t-statistics* results are not significant for hedge ratio β traded at Singapore. With the acceptable standard errors, the results once again confirm that the shorter the forward period, the higher the hedging effectiveness is.

Using a cross-hedge with WTI crude oil and heating oil futures contracts traded at NYMEX

New York Mercantile Exchange is world's largest physical commodity futures exchange and established for more than 130 years ago. Trading is conducted through two divisions the NYMEX Division and COMEX Division. Energy futures are traded on the NYMEX Division. The standard contract is of 1,000 barrels. Crude oil spot and futures are quoted in US dollars per barrel while heating is quoted in US dollar per gallon. Trading is open for every member from Monday to Friday.

Futures contracts for WTI crude and heating oil include four kinds: Contract 1, Contract 2, Contract 3 and Contract 4. For heating oil, Contract 1 expires on last business day of the month preceding delivery month. The delivery month of Contract 1 is the calendar month following the trade date? For crude oil, Contract 1 expires on the third business day prior to the 25th calendar day of the month preceding the delivery month. If the 25th calendar day of the month is a non-business day, trading ceases on the third business day prior to the business day preceding the 25th calendar day. Contracts 2, 3 and 4 represent the successive delivery months following Contract 1.

Data collection

Weekly bunker spot prices for Singapore, Fujairah and Mundra are collected from various issues of Fairplay Weekly published on Monday from 01/01/1990 to 31/12/2016 (909 observations). Spot and futures energy prices traded at NYMEX including WTI crude oil and heating oil (Contracts 1, 2, 3 and 4) are obtained on a weekly-base from the website of the Energy Information Administration of the US Government. Futures prices are the closing prices on Friday of each week. The data range of WTI crude price is from 05/01/1990 to 31/12/2016 (909 observations). The data range of heating oil Contracts 1 and 3 are for the same period while futures Contract 2 are from 04/02/1994 to 31/12/2016 (696 observations) and futures Contract 4 are from 14/01/1994 to 31/12/2016 (699 observations).

It is understood that all energy futures prices are strongly correlated with bunker spot prices on three markets i.e. Singapore, Fujairah and Mundra. Typically, returns on bunker spot prices are

more correlated to WTI crude Contracts than heating oil contracts. Correlations are especially high between Fujairah and Singapore bunker spot prices and WTI crude contracts. As a result, this may suggest that WTI crude contracts are better for hedging against bunker spot prices fluctuation than heating oil contracts.

Estimate the hedge ratio and hedging effectiveness

Jarque & Bera (1980) test for normal distribution of bunker spot and energy futures prices and Philips & Perron (1988) test for the stationarity of the bunker spot and futures energy prices series are deployed to test the fitness of the data ranges with OLS regression operation. Moreover, mean and standard deviation methods are also applied to know the fluctuation of the bunker spot and energy futures prices.

Chapter conclusion

Results obtained from OLS estimations for a direct-hedge with bunker forward contracts and a cross-hedge with different energy futures contracts once again confirm Marshall's statement in chapter 2 that "a direct-hedge is usually more effective than a cross-hedge" (1989, p. 200). Compared with a direct-hedge, the best hedging effectiveness of a cross- hedge falls in WTI crude futures Contracts 3, 4, 2 and 1 with a risk reduction of 26.48%, 26.42%, 26.35% and 23.61% respectively when hedging against bunker spot price fluctuation in Fujairah.

In contrast, a direct-hedge with 1-month and 12-month bunker forward contracts could result in the risk reduction of 83.14% (hedge ratio = 0.913615) and 62.49% (hedge ratio = 0.899641) respectively when hedging Fujairah bunker spot price and 75.93% (hedge ratio = 0.786798) and 59.01% (hedge ratio = 0.689305) respectively when hedging against the bunker spot prices fluctuation in Singapore.

CHAPTER 6 CONCLUSION

- Dissertation contributes to the literature on study of shipping sector. Some basic concepts of the futures markets, spot market and hedging have been shown for proper understanding and their use in hedging. Healthy review of hedging in general and particularly in the shipping sector, such as hedging bunker prices and hedging freight rates is provided to address the matter of shipping risks in the way the industry to minimize such risks.

- A systematic series of data from 2005 to 2016 about world economy, world oil production and consumption, world tonnage, world merchandise export value world oil refining capacity and refining marginal costs, world bunker supply and demand, international seaborne trade, time charter rates, international seaborne trade bunker prices, oil prices, speed and fuel consumption of vessels has been collected from leading Shipping Magazines such as Port wings, Drewry Monthly, Review of Maritime Transport for quantifying works in this dissertation.

- Statistical methods of *standard deviation and mean have been used* to explain the behaviour of bunker prices from 2005 to 2016 where the period 2015-2016 is shown by low levels and stable prices while the period 2014 is dotted with unpredictable behaviour with sky high prices and abnormal fluctuations. An economic analysis of the bunker market is provided, the laws of demand and supply are applied to explain the unpredictable behaviour of bunker prices.

- Sky-high crude oil price, the all time high oil consumption levels and low oil production capacity, fierce competition overseas, the limits of refining capacity of the world and main ports, and in local ports as well as the bunkering methodologies. Demand side increase in bunker price is derived from increase in

world's economy, the boom in international seaborne trade, the fast development of world tonnage, the high freight rate levels as well as the bigger size and higher fuel consumption of world ships.

- C*orrelation* method is used to investigate the most important factors of bunker market. The results prove that international seaborne trade, time charter rates crude oil prices and fuel consumption have a strong correlation with bunker prices. Such factors contribute in driving the bunker market over the last 16 years (2005 - 2016).

- Hedging instruments, including, bunker forward contracts, energy futures contracts, bunker options agreement as well as bunker swaps agreement for the wide choices of ship operators and ship owners in hedging their bunker price fluctuations. Some practical examples taken from the data provided to prove the hedging functions of the four instruments.

- Some methodology for estimating hedging effectiveness and hedge ratio are analysed. Ordinary Least Squares (OLS) regression model is used. Practical work has been done to investigate the hedging effectiveness of a cross-hedge with different energy futures contracts and direct-hedge with bunker forward contracts. Comparison with direct- respectively when hedging against prices of bunker spot fluctuation in Fujairah & Mundra.

This dissertation bring important implication for ship owners, ship operators & related parties who wish to reduce bunker price risks by hedging.

- The price variation in the bunker industry is because various factors such as number of ships, crude oil prices, demand & supply of bunker oil, capacity of refineries to produce bunker oil, GDP of the country, loading & unloading business of the shipping industries, types of ships etc.

- Bunker business of Singapore seems to be good in terms of bunker hedging because this port has a good capacity to handle various cargoes at a particular time, the bunker supply & handling capacity is very much high.

- Bunker hedging at Mundra port is not a right decision because of the high price of bunker oil & when the vessels go through this way they can either take bunker oil from Fujairah or Singapore because both port have lower prices as compared to Mundra port. Vessel only consume bunker oil from these ports for their consumption till Singapore or Fujairah & from there on they take big quantum of oil for further voyage. It has been seen from the data that the price difference from the Singapore to the Mundra port is huge that is nearly $40 and Singapore to Fujairah is of +/-$2. So in order to consume oil the ship prefer to take oil from Singapore or Fujairah instead of Mundra port.

Limitation of analysis

- The purpose to go deeply inside to study the crude heating oil futures and WTI Contracts traded at NYMEX has limited the paper from choosing other energy traded on other markets such as Gas oil, Brent crude (traded at IPE London) for a wider choice of market participants. It seems that the OLS regression model is suitable for estimating hedge ratio and hedging effectiveness with big observations.

- The data available for the dissertation is taken in consideration by variation in the bunker prices of Singapore that is the data shown in the dissertation has been taken from various sites and with help of industrial experts who are presently working in the bunker market in their respective firms.

- The bunker market is very volatile it can change because of any of the factor mentioned prior because this industry is totally dependent on the prices of crude oil & any change in the crude oil prices may lead to +/-$5 change in the bunker industry.

APPENDIX

WEEKLY AVERAGE PRICE OF IFO-380

Year	MONTH	DATE	Fujairah	Singapore	Mundra
2005	1	3-Jan	137	141	171
2005	1	10-Jan	145	149	179
2005	1	17-Jan	159.5	163.5	193.5
2005	1	24-Jan	164.5	168.5	198.5
2005	1	31-Jan	153	157	187
2005	2	7-Feb	161	165	195
2005	2	14-Feb	164	168	198
2005	2	21-Feb	171	175	205
2005	2	28-Feb	183	187	217
2005	3	7-Mar	190	194	224
2005	3	14-Mar	199.5	203.5	233.5
2005	3	21-Mar	199.5	203.5	233.5
2005	3	28-Mar	203	207	237
2005	4	4-Apr	226.5	230.5	260.5
2005	4	11-Apr	231	235	265
2005	4	18-Apr	207	211	241
2005	4	25-Apr	243	247	277
2005	5	2-May	238	242	272
2005	5	9-May	229.5	233.5	263.5
2005	5	16-May	225	229	259
2005	5	23-May	221.5	225.5	255.5
2005	5	30-May	215	219	249
2005	6	6-Jun	234.5	238.5	268.5
2005	6	13-Jun	235	239	269
2005	6	20-Jun	239	243	273
2005	6	27-Jun	247.5	251.5	281.5
2005	7	4-Jul	242.5	246.5	276.5
2005	7	11-Jul	253	257	287
2005	7	18-Jul	247	251	281
2005	7	25-Jul	242	246	276
2005	8	1-Aug	242	246	276
2005	8	8-Aug	257	261	291
2005	8	15-Aug	267	271	301
2005	8	22-Aug	266	270	300

2005	8	29-Aug	271	275	305
2005	9	5-Sep	286	290	320
2005	9	12-Sep	263.5	267.5	297.5
2005	9	19-Sep	270.5	274.5	304.5
2005	9	26-Sep	276	280	310
2005	10	3-Oct	283	287	317
2005	10	10-Oct	268	272	302
2005	10	17-Oct	274	278	308
2005	10	24-Oct	258.5	262.5	292.5
2005	10	31-Oct	258.5	262.5	292.5
2005	11	7-Nov	257	261	291
2005	11	14-Nov	246	250	280
2005	11	21-Nov	251	255	285
2005	11	28-Nov	242.5	246.5	276.5
2005	12	5-Dec	260.5	264.5	294.5
2005	12	12-Dec	261	265	295
2005	12	19-Dec	252	256	286
2005	12	26-Dec	254	258	288
2006	1	2-Jan	259	263	293
2006	1	9-Jan	275.5	279.5	309.5
2006	1	16-Jan	279	283	313
2006	1	23-Jan	298	302	332
2006	1	30-Jan	297	301	331
2006	2	6-Feb	299.5	303.5	333.5
2006	2	13-Feb	295	299	329
2006	2	20-Feb	287	291	321
2006	2	27-Feb	294	298	328
2006	3	6-Mar	289.5	293.5	323.5
2006	3	13-Mar	283	287	317
2006	3	20-Mar	292.5	296.5	326.5
2006	3	27-Mar	298	302	332
2006	4	3-Apr	312	316	346
2006	4	10-Apr	312	316	346
2006	4	17-Apr	313.5	317.5	347.5
2006	4	24-Apr	326.5	330.5	360.5
2006	5	1-May	320	324	354
2006	5	8-May	320	324	354
2006	5	15-May	316.5	320.5	350.5

2006	5	22-May	313.5	317.5	347.5
2006	5	29-May	316	320	350
2006	6	5-Jun	312	316	346
2006	6	12-Jun	306	310	340
2006	6	19-Jun	287.5	291.5	321.5
2006	6	26-Jun	291	295	325
2006	7	3-Jul	300	304	334
2006	7	10-Jul	297	301	331
2006	7	17-Jul	331	335	365
2006	7	24-Jul	312.5	316.5	346.5
2006	7	31-Jul	313.5	317.5	347.5
2006	8	7-Aug	317.5	321.5	351.5
2006	8	14-Aug	309	313	343
2006	8	21-Aug	310	314	344
2006	8	28-Aug	291	295	325
2006	9	4-Sep	282	286	316
2006	9	11-Sep	274	278	308
2006	9	18-Sep	272	276	306
2006	9	25-Sep	253.5	257.5	287.5
2006	10	2-Oct	264	268	298
2006	10	9-Oct	364.5	368.5	398.5
2006	10	16-Oct	266	270	300
2006	10	23-Oct	255	259	289
2006	10	30-Oct	254.5	258.5	288.5
2006	11	6-Nov	256.5	260.5	290.5
2006	11	13-Nov	259	263	293
2006	11	20-Nov	251	255	285
2006	11	27-Nov	249	253	283
2006	12	4-Dec	251	255	285
2006	12	11-Dec	254.5	258.5	288.5
2006	12	18-Dec	256.5	260.5	290.5
2006	12	25-Dec	256	260	290
2007	1	1-Jan	229	233	263
2007	1	8-Jan	232	236	266
2007	1	15-Jan	226	230	260
2007	1	22-Jan	205.5	209.5	239.5
2007	1	29-Jan	217.5	221.5	251.5
2007	2	5-Feb	247.5	251.5	281.5

2007	2	12-Feb	256	260	290
2007	2	19-Feb	245.5	249.5	279.5
2007	2	26-Feb	261	265	295
2007	3	5-Mar	257.5	261.5	291.5
2007	3	12-Mar	254.5	258.5	288.5
2007	3	19-Mar	259	263	293
2007	3	26-Mar	277	281	311
2007	4	2-Apr	294	298	328
2007	4	9-Apr	293.5	297.5	327.5
2007	4	16-Apr	301.5	305.5	335.5
2007	4	23-Apr	307	311	341
2007	4	30-Apr	331	335	365
2007	5	7-May	322	326	356
2007	5	14-May	318.5	322.5	352.5
2007	5	21-May	317	321	351
2007	5	28-May	319	323	353
2007	6	4-Jun	338	342	372
2007	6	11-Jun	345	349	379
2007	6	18-Jun	352	356	386
2007	6	25-Jun	351	355	385
2007	7	2-Jul	347	351	381
2007	7	9-Jul	360	364	394
2007	7	16-Jul	359	363	393
2007	7	23-Jul	363	367	397
2007	7	30-Jul	366	370	400
2007	8	6-Aug	354	358	388
2007	8	13-Aug	348	352	382
2007	8	20-Aug	343	347	377
2007	8	27-Aug	336	340	370
2007	9	3-Sep	353	357	387
2007	9	10-Sep	361	365	395
2007	9	17-Sep	368	372	402
2007	9	24-Sep	376	380	410
2007	10	1-Oct	387	391	421
2007	10	8-Oct	398	402	432
2007	10	15-Oct	410	414	444
2007	10	22-Oct	422	426	456
2007	10	29-Oct	437	441	471

2007	11	5-Nov	450	454	484
2007	11	12-Nov	468	472	502
2007	11	19-Nov	482	486	516
2007	11	26-Nov	512	516	546
2007	12	3-Dec	477	481	511
2007	12	10-Dec	42	46	76
2007	12	17-Dec	437	441	471
2007	12	24-Dec	452	456	486
2008	1	1-Jan	484	488	518
2008	1	8-Jan	468	472	502
2008	1	15-Jan	437	441	471
2008	1	22-Jan	422	426	456
2008	1	29-Jan	412	416	446
2008	2	5-Feb	424	428	458
2008	2	12-Feb	435	439	469
2008	2	19-Feb	447	451	481
2008	2	26-Feb	452	456	486
2008	3	5-Mar	442	446	476
2008	3	12-Mar	457	461	491
2008	3	19-Mar	461	465	495
2008	3	26-Mar	462	466	496
2008	4	2-Apr	477	481	511
2008	4	9-Apr	490	494	524
2008	4	16-Apr	495	499	529
2008	4	23-Apr	508	512	542
2008	4	30-Apr	512	516	546
2008	5	7-May	567	571	601
2008	5	14-May	572	576	606
2008	5	21-May	592	596	626
2008	5	28-May	600	604	634
2008	6	4-Jun	604	608	638
2008	6	11-Jun	609	613	643
2008	6	18-Jun	615	619	649
2008	6	25-Jun	617	621	651
2008	7	2-Jul	642	646	676
2008	7	9-Jul	682	686	716
2008	7	16-Jul	637	641	671
2008	7	23-Jul	617	621	651

2008	7	30-Jul	627	631	661
2008	8	6-Aug	639	643	673
2008	8	13-Aug	661	665	695
2008	8	20-Aug	677	681	711
2008	8	27-Aug	692	696	726
2008	9	3-Sep	668	672	702
2008	9	10-Sep	649	653	683
2008	9	17-Sep	592	596	626
2008	9	24-Sep	477	481	511
2008	10	1-Oct	422	426	456
2008	10	8-Oct	393	397	427
2008	10	15-Oct	310	314	344
2008	10	22-Oct	262	266	296
2008	10	29-Oct	248	252	282
2008	11	5-Nov	246	250	280
2008	11	12-Nov	227	231	261
2008	11	19-Nov	212	216	246
2008	11	26-Nov	210	214	244
2008	12	3-Dec	205	209	239
2008	12	10-Dec	197	201	231
2008	12	17-Dec	192	196	226
2008	12	24-Dec	202	206	236
2008	12	31-Dec	227	231	261

YR: 2005- 2008			Fujairah	Singapore	Mundra
Mean			331.61	335.61	365.61
ST. Deviation			124.613	127.4125	122.4395
MAX			692	696	726
MIN			42	46	76

Year	MONTH	DATE	Fujairah	Singapore	Mundra
2009	1	1-Jan	206	210	240
2009	1	8-Jan	208	212	242
2009	1	15-Jan	210	214	244
2009	1	22-Jan	206	210	240
2009	1	29-Jan	210	214	244
2009	2	5-Feb	211	215	245

2009	2	12-Feb	212	216	246
2009	2	19-Feb	213	217	247
2009	2	26-Feb	214	218	248
2009	3	5-Mar	216	220	250
2009	3	12-Mar	221	225	255
2009	3	19-Mar	229	233	263
2009	3	26-Mar	233	237	267
2009	4	2-Apr	236	240	270
2009	4	9-Apr	251	255	285
2009	4	16-Apr	263	267	297
2009	4	23-Apr	285	289	319
2009	4	30-Apr	315	319	349
2009	5	7-May	336	340	370
2009	5	14-May	352	356	386
2009	5	21-May	363	367	397
2009	5	28-May	383	387	417
2009	6	4-Jun	396	400	430
2009	6	11-Jun	401	405	435
2009	6	18-Jun	408	412	442
2009	6	25-Jun	202	206	236
2009	7	2-Jul	396	400	430
2009	7	9-Jul	399	403	433
2009	7	16-Jul	402	406	436
2009	7	23-Jul	404	408	438
2009	7	30-Jul	399	403	433
2009	8	6-Aug	401	405	435
2009	8	13-Aug	402	406	436
2009	8	20-Aug	404	408	438
2009	8	27-Aug	400	404	434
2009	9	3-Sep	399	403	433
2009	9	10-Sep	402	406	436
2009	9	17-Sep	403	407	437
2009	9	24-Sep	405	409	439
2009	10	1-Oct	406	410	440
2009	10	8-Oct	411	415	445
2009	10	15-Oct	414	418	448
2009	10	22-Oct	417	421	451
2009	10	29-Oct	419	423	453

2009	11	5-Nov	421	425	455
2009	11	12-Nov	432	436	466
2009	11	19-Nov	430	434	464
2009	11	26-Nov	433	437	467
2009	12	3-Dec	436	440	470
2009	12	10-Dec	440	444	474
2009	12	17-Dec	455	459	489
2009	12	24-Dec	461	465	495
2009	12	31-Dec	467	471	501
2010	1	1-Jan	485	489	519
2010	1	8-Jan	491	495	525
2010	1	15-Jan	499	503	533
2010	1	22-Jan	481	485	515
2010	1	29-Jan	472	476	506
2010	2	5-Feb	477	481	511
2010	2	12-Feb	481	485	515
2010	2	19-Feb	483	487	517
2010	2	26-Feb	484	488	518
2010	3	5-Mar	486	490	520
2010	3	12-Mar	488	492	522
2010	3	19-Mar	488	492	522
2010	3	26-Mar	491	495	525
2010	4	2-Apr	492	496	526
2010	4	9-Apr	494	498	528
2010	4	16-Apr	492	496	526
2010	4	23-Apr	493	497	527
2010	4	30-Apr	497	501	531
2010	5	7-May	498	502	532
2010	5	14-May	467	471	501
2010	5	21-May	460	464	494
2010	5	28-May	435	439	469
2010	6	4-Jun	415	419	449
2010	6	11-Jun	421	425	455
2010	6	18-Jun	455	459	489
2010	6	25-Jun	419	423	453
2010	7	2-Jul	406	410	440
2010	7	9-Jul	415	419	449
2010	7	16-Jul	428	432	462

2010	7	23-Jul	435	439	469
2010	7	30-Jul	441	445	475
2010	8	6-Aug	446	450	480
2010	8	13-Aug	440	444	474
2010	8	20-Aug	435	439	469
2010	8	27-Aug	423	427	457
2010	9	3-Sep	416	420	450
2010	9	10-Sep	421	425	455
2010	9	17-Sep	417	421	451
2010	9	24-Sep	422	426	456
2010	10	1-Oct	425	429	459
2010	10	8-Oct	432	436	466
2010	10	15-Oct	445	449	479
2010	10	22-Oct	455	459	489
2010	10	29-Oct	465	469	499
2010	11	5-Nov	483	487	517
2010	11	12-Nov	484	488	518
2010	11	19-Nov	488	492	522
2010	11	26-Nov	490	494	524
2010	12	3-Dec	492	496	526
2010	12	10-Dec	488	492	522
2010	12	17-Dec	486	490	520
2010	12	24-Dec	483	487	517
2010	12	31-Dec	481	485	515
2011	1	1-Jan	496	500	530
2011	1	8-Jan	522	526	556
2011	1	15-Jan	539	543	573
2011	1	22-Jan	565	569	599
2011	1	29-Jan	582	586	616
2011	2	5-Feb	596	600	630
2011	2	12-Feb	611	615	645
2011	2	19-Feb	619	623	653
2011	2	26-Feb	623	627	657
2011	3	5-Mar	626	630	660
2011	3	12-Mar	628	632	662
2011	3	19-Mar	630	634	664
2011	3	26-Mar	627	631	661
2011	4	2-Apr	626	630	660

2011	4	9-Apr	641	645	675
2011	4	16-Apr	650	654	684
2011	4	23-Apr	657	661	691
2011	4	30-Apr	665	669	699
2011	5	7-May	671	675	705
2011	5	14-May	655	659	689
2011	5	21-May	636	640	670
2011	5	28-May	621	625	655
2011	6	4-Jun	611	615	645
2011	6	11-Jun	614	618	648
2011	6	18-Jun	617	621	651
2011	6	25-Jun	619	623	653
2011	7	2-Jul	621	625	655
2011	7	9-Jul	635	639	669
2011	7	16-Jul	647	651	681
2011	7	23-Jul	662	666	696
2011	7	30-Jul	673	677	707
2011	8	6-Aug	681	685	715
2011	8	13-Aug	677	681	711
2011	8	20-Aug	675	679	709
2011	8	27-Aug	665	669	699
2011	9	3-Sep	650	654	684
2011	9	10-Sep	635	639	669
2011	9	17-Sep	623	627	657
2011	9	24-Sep	621	625	655
2011	10	1-Oct	633	637	667
2011	10	8-Oct	648	652	682
2011	10	15-Oct	665	669	699
2011	10	22-Oct	652	656	686
2011	10	29-Oct	645	649	679
2011	11	5-Nov	652	656	686
2011	11	12-Nov	657	661	691
2011	11	19-Nov	653	657	687
2011	11	26-Nov	646	650	680
2011	12	3-Dec	635	639	669
2011	12	10-Dec	621	625	655
2011	12	17-Dec	626	630	660
2011	12	24-Dec	643	647	677

2011	12	31-Dec	649	653	683
2012	1	1-Jan	626	630	660
2012	1	8-Jan	638	642	672
2012	1	15-Jan	654	658	688
2012	1	22-Jan	663	667	697
2012	1	29-Jan	685	689	719
2012	2	5-Feb	688	692	722
2012	2	12-Feb	694	698	728
2012	2	19-Feb	699	703	733
2012	2	26-Feb	705	709	739
2012	3	5-Mar	710	714	744
2012	3	12-Mar	713	717	747
2012	3	19-Mar	716	720	750
2012	3	26-Mar	721	725	755
2012	4	2-Apr	714	718	748
2012	4	9-Apr	709	713	743
2012	4	16-Apr	701	705	735
2012	4	23-Apr	696	700	730
2012	4	30-Apr	685	689	719
2012	5	7-May	667	671	701
2012	5	14-May	659	663	693
2012	5	21-May	647	651	681
2012	5	28-May	631	635	665
2012	6	4-Jun	624	628	658
2012	6	11-Jun	621	625	655
2012	6	18-Jun	623	627	657
2012	6	25-Jun	617	621	651
2012	7	2-Jul	614	618	648
2012	7	9-Jul	611	615	645
2012	7	16-Jul	612	616	646
2012	7	23-Jul	606	610	640
2012	7	30-Jul	613	617	647
2012	8	6-Aug	625	629	659
2012	8	13-Aug	641	645	675
2012	8	20-Aug	652	656	686
2012	8	27-Aug	661	665	695
2012	9	3-Sep	666	670	700
2012	9	10-Sep	668	672	702

2012	9	17-Sep	662	666	696
2012	9	24-Sep	657	661	691
2012	10	1-Oct	653	657	687
2012	10	8-Oct	655	659	689
2012	10	15-Oct	648	652	682
2012	10	22-Oct	646	650	680
2012	10	29-Oct	644	648	678
2012	11	5-Nov	606	610	640
2012	11	12-Nov	614	618	648
2012	11	19-Nov	612	616	646
2012	11	26-Nov	602	606	636
2012	12	3-Dec	596	600	630
2012	12	10-Dec	592	596	626
2012	12	17-Dec	604	608	638
2012	12	24-Dec	598	602	632
2012	12	31-Dec	605	609	639

WTI Prices

Day	Cushing OK WTI Spot Price FOB Dollars per Barrel
12/29/2016	53.8
12/22/2016	51.98
12/15/2016	50.9
12/8/2016	50.84
12/1/2016	51.08
11/17/2016	45.37
11/10/2016	44.62
11/3/2016	44.66
10/27/2016	49.71
10/20/2016	50.31
10/13/2016	50.47
10/6/2016	50.44
9/29/2016	47.72
9/22/2016	46.1
9/15/2016	43.85
9/8/2016	47.63
9/1/2016	43.17
8/25/2016	46.97

8/18/2016	48.2
8/11/2016	43.51
8/4/2016	41.92
7/28/2016	41.13
7/21/2016	43.96
7/14/2016	45.64
7/7/2016	45.22
6/30/2016	48.27
6/23/2016	49.34
6/16/2016	46.14
6/9/2016	50.52
6/2/2016	49.14
5/26/2016	49
5/19/2016	48.16
5/12/2016	46.64
5/5/2016	44.33
4/28/2016	46.03
4/21/2016	43.18
4/14/2016	41.45
4/7/2016	37.3
3/31/2016	36.94
3/24/2016	38.14
3/17/2016	40.17
3/10/2016	37.77
3/3/2016	34.56
2/25/2016	31.4
2/18/2016	30.77
2/11/2016	26.19
2/4/2016	31.63
1/28/2016	33.21
1/21/2016	29.55
1/14/2016	31.22
1/7/2016	33.29
12/31/2015	37.13
12/24/2015	37.62
12/17/2015	34.98
12/10/2015	36.76
12/3/2015	41.08

11/19/2015	40.55
11/12/2015	41.74
11/5/2015	45.27
10/29/2015	46.02
10/22/2015	44.9
10/15/2015	46.38
10/8/2015	49.46
10/1/2015	44.75
9/24/2015	44.94
9/17/2015	46.93
9/10/2015	45.85
9/3/2015	46.75
8/27/2015	42.47
8/20/2015	41
8/13/2015	42.27
8/6/2015	44.69
7/30/2015	48.53
7/23/2015	48.11
7/16/2015	50.9
7/9/2015	52.76
7/2/2015	56.93
6/25/2015	59.59
6/18/2015	60.41
6/11/2015	60.74
6/4/2015	58
5/28/2015	57.69
5/21/2015	60.18
5/14/2015	59.89
5/7/2015	58.99
4/30/2015	59.62
4/23/2015	56.59
4/16/2015	56.69
4/9/2015	50.79
4/2/2015	49.13
3/26/2015	51.41
3/19/2015	44.02
3/12/2015	47.12
3/5/2015	50.76

2/26/2015	47.65
2/19/2015	51.12
2/12/2015	51.17
2/5/2015	50.48
1/29/2015	44.12
1/22/2015	45.93
1/15/2015	46.37
1/8/2015	48.8
12/31/2014	53.45
12/24/2014	55.7
12/17/2014	56.43
12/10/2014	60.99
12/3/2014	67.3
11/26/2014	73.7
11/19/2014	74.55
11/12/2014	77.16
11/5/2014	78.71
10/29/2014	82.25
10/22/2014	80.52
10/15/2014	81.82
10/8/2014	87.29
10/1/2014	90.74
9/24/2014	93.6
9/17/2014	94.33
9/10/2014	91.71
9/3/2014	95.5
8/27/2014	95.82
8/20/2014	96.4
8/13/2014	97.57
8/6/2014	96.93
7/30/2014	104.29
7/23/2014	103.81
7/16/2014	101.88
7/9/2014	102.93
7/2/2014	105.18
6/25/2014	107.04
6/18/2014	106.64
6/11/2014	105.04

6/4/2014	103.27
5/28/2014	103.37
5/21/2014	104.31
5/14/2014	102.63
5/7/2014	101.06
4/30/2014	100.07
4/23/2014	101.47
4/16/2014	103.71
4/9/2014	103.55
4/2/2014	99.6
3/26/2014	100.61
3/19/2014	100.71
3/12/2014	98.29
3/5/2014	101.75
2/26/2014	102.93
2/19/2014	103.46
2/12/2014	100.38
2/5/2014	97.4
1/29/2014	97.34
1/22/2014	96.35
1/15/2014	93.78
1/8/2014	91.9
12/31/2013	98.17
12/24/2013	98.87
12/17/2013	96.99
12/10/2013	98.32
12/3/2013	95.83
11/26/2013	93.41
11/19/2013	93.35
11/12/2013	93.12
11/5/2013	93.4
10/29/2013	98.29
10/22/2013	97.63
10/15/2013	101.15
10/8/2013	103.54
10/1/2013	102.09
9/24/2013	103.22
9/17/2013	105.36

9/10/2013	107.48
9/3/2013	108.67
8/27/2013	109.11
8/20/2013	104.9
8/13/2013	106.78
8/6/2013	105.32
7/30/2013	103.14
7/23/2013	107.13
7/16/2013	105.88
7/9/2013	103.46
7/2/2013	99.65
6/25/2013	95.25
6/18/2013	98.46
6/11/2013	95.5
6/4/2013	93.36
5/28/2013	94.65
5/21/2013	95.55
5/14/2013	93.96
5/7/2013	95.28
4/30/2013	93.22
4/23/2013	89.21
4/16/2013	88.73
4/9/2013	94.18
4/2/2013	97.23
3/26/2013	95.99
3/19/2013	92.44
3/12/2013	92.44
3/5/2013	90.88
2/26/2013	92.63
2/19/2013	96.69
2/12/2013	97.48
2/5/2013	96.68
1/29/2013	97.62
1/22/2013	96.09
1/15/2013	93.26
1/8/2013	93.21
12/31/2010	91.38
12/17/2010	88.02

12/10/2010	87.81
12/3/2010	89.18
11/26/2010	83.87
11/19/2010	81.65
11/12/2010	84.89
11/5/2010	86.85
10/29/2010	81.45
10/22/2010	81.15
10/15/2010	81.23
10/8/2010	82.66
10/1/2010	81.57
9/24/2010	74.63
9/17/2010	73.63
9/10/2010	76.4
9/3/2010	74.52
8/27/2010	75.17
8/20/2010	73.45
8/13/2010	75.39
8/6/2010	80.67
7/30/2010	78.85
7/23/2010	78.68
7/16/2010	75.96
7/9/2010	76.08
7/2/2010	72.06
6/25/2010	78.45
6/18/2010	77.18
6/11/2010	73.89
6/4/2010	71.43
5/28/2010	74
5/21/2010	68.03
5/14/2010	71.61
5/7/2010	75.1
4/30/2010	86.07
4/23/2010	84.34
4/16/2010	82.97
4/9/2010	84.6
3/26/2010	79.75
3/19/2010	80.58

3/12/2010	81.26
3/5/2010	81.5
2/26/2010	79.72
2/19/2010	79.77
2/12/2010	74.11
2/5/2010	71.15
1/29/2010	72.85
1/22/2010	74.25
1/15/2010	77.96
1/8/2010	82.74
12/31/2009	79.39
12/24/2009	76.83
12/17/2009	72.58
12/10/2009	70.54
12/3/2009	76.42
11/19/2009	77.47
11/12/2009	77.25
11/5/2009	79.64
10/29/2009	79.84
10/22/2009	80.82
10/15/2009	77.55
10/8/2009	71.69
10/1/2009	70.67
9/24/2009	65.74
9/17/2009	72.48
9/10/2009	71.95
9/3/2009	67.9
8/27/2009	72.49
8/20/2009	72.4
8/13/2009	70.57
8/6/2009	71.96
7/30/2009	66.9
7/23/2009	66.1
7/16/2009	62.07
7/9/2009	60.36
7/2/2009	66.68
6/25/2009	69.7
6/18/2009	71.42

6/11/2009	72.69
6/4/2009	68.8
5/28/2009	65.09
5/21/2009	60.49
5/14/2009	58.58
5/7/2009	56.67
4/30/2009	50.35
4/23/2009	48.46
4/16/2009	49.97
4/9/2009	52.24
4/2/2009	52.61
3/26/2009	53.87
3/19/2009	51.46
3/12/2009	46.91
3/5/2009	43.54
2/26/2009	43.18
2/19/2009	39.6
2/12/2009	34.03
2/5/2009	41.15
1/29/2009	41.58
1/22/2009	42.33
1/15/2009	35.41
1/8/2009	41.68
12/30/2008	38.95
12/23/2008	30.28
12/16/2008	43.84
12/9/2008	42
12/2/2008	47.05
11/25/2008	50.02
11/18/2008	54.42
11/11/2008	59.38
11/4/2008	70.41
10/28/2008	62.8
10/21/2008	71.29
10/14/2008	78.69
10/7/2008	90.18
9/30/2008	100.7
9/23/2008	107.85

9/16/2008	91.49
9/9/2008	103.23
9/2/2008	109.63
8/26/2008	116.31
8/19/2008	114.39
8/12/2008	113.1
8/5/2008	118.71
7/29/2008	122.21
7/22/2008	127.25
7/15/2008	138.68
7/8/2008	136.06
7/1/2008	141.06
6/24/2008	136.49
6/17/2008	133.99
6/10/2008	131.38
6/3/2008	124.33
5/27/2008	128.81
5/20/2008	128.93
5/13/2008	125.83
5/6/2008	121.82
4/29/2008	115.67
4/22/2008	119.17
4/15/2008	113.77
4/8/2008	108.54
4/1/2008	100.92
3/25/2008	101.78
3/18/2008	109.57
3/11/2008	108.73
3/4/2008	99.72
2/26/2008	100.83
2/19/2008	99.99
2/12/2008	92.82
2/5/2008	88.32
1/29/2008	91.66
1/22/2008	89.64
1/15/2008	91.87
1/8/2008	96.43
12/24/2007	94

12/17/2007	90.69
12/10/2007	87.72
12/3/2007	89.29
11/26/2007	97.66
11/19/2007	95.75
11/12/2007	94.4
11/5/2007	94.06
10/29/2007	93.45
10/22/2007	87.6
10/15/2007	86.19
10/8/2007	78.97
10/1/2007	80.31
9/24/2007	82.51
9/17/2007	80.55
9/10/2007	77.53
8/27/2007	71.98
8/20/2007	71.12
8/13/2007	71.6
8/6/2007	72.03
7/30/2007	76.82
7/23/2007	74.65
7/16/2007	74.11
7/9/2007	72.14
7/2/2007	71.11
6/25/2007	68.83
6/18/2007	69.06
6/11/2007	65.93
6/4/2007	66.17
5/21/2007	66.25
5/14/2007	62.55
5/7/2007	61.48
4/30/2007	65.78
4/23/2007	65.33
4/16/2007	63.63
4/9/2007	61.51
4/2/2007	66.03
3/26/2007	61.77
3/19/2007	56.65

3/12/2007	58.94
3/5/2007	60.05
2/26/2007	61.41
2/12/2007	57.76
2/5/2007	58.69
1/29/2007	54.01
1/22/2007	51.11
1/8/2007	56.08
12/18/2006	62.19
12/11/2006	61.26
12/4/2006	62.39
11/27/2006	60.3
11/20/2006	56.42
11/13/2006	58.59
11/6/2006	60.11
10/30/2006	58.41
10/23/2006	56.74
10/16/2006	59.91
10/9/2006	59.93
10/2/2006	60.96
9/25/2006	60.74
9/18/2006	63.84
9/11/2006	65.42
8/28/2006	70.47
8/21/2006	72.45
8/14/2006	73.33
8/7/2006	77.05
7/31/2006	74.56
7/24/2006	74.29
7/17/2006	75.7
7/10/2006	73.5
6/26/2006	71.63
6/19/2006	69.21
6/12/2006	70.28
6/5/2006	72.5
5/22/2006	69.23
5/15/2006	69.25
5/8/2006	69.75

5/1/2006	73.75
4/24/2006	70.19
4/17/2006	70.3
4/10/2006	68.29
4/3/2006	66.07
3/27/2006	63.75
3/20/2006	60.31
3/13/2006	61.81
3/6/2006	62.46
2/27/2006	61.01
2/13/2006	61.26
2/6/2006	65.11
1/30/2006	68.36
1/23/2006	68.06
1/9/2006	63.56
12/19/2005	57.31
12/12/2005	61.36
12/5/2005	59.91
11/28/2005	57.36
11/21/2005	57.75
11/14/2005	57.6
11/7/2005	59.4
10/31/2005	59.8
10/24/2005	60.63
10/17/2005	64.26
10/10/2005	60.71
10/3/2005	65.36
9/26/2005	65.98
9/19/2005	67.21
9/12/2005	63.29
8/29/2005	67.41
8/22/2005	65.46
8/15/2005	66.21
8/8/2005	63.92
8/1/2005	61.51
7/25/2005	58.16
7/18/2005	57.12
7/11/2005	59.23

6/27/2005	59.78
6/20/2005	59.19
6/13/2005	55.47
6/6/2005	54.46
5/23/2005	48.68
5/16/2005	48.64
5/9/2005	52.04
5/2/2005	50.94
4/25/2005	53.16
4/18/2005	50.52
4/11/2005	53.71
4/4/2005	56.86
3/28/2005	54.06
3/21/2005	56.7
3/14/2005	54.9
3/7/2005	53.9
2/28/2005	51.75
2/14/2005	47.5
2/7/2005	45.35
1/31/2005	48.25
1/24/2005	48.61
1/10/2005	45.31
1/3/2005	42.16

DESCRIPTIVE STATISTICS (BUNKER PRICES – FUJAIRAH)

Summary Statistics

Average:	383.7254
Standard Deviation:	144.7671
Skew:	0.29
Excess Kurtosis:	-1.15
Median:	359
Minimum:	42
Maximum:	692
1st Quartile:	256.9
3rd Quartile:	492

Significance Test		**5.00%**
Target	**P-Value**	**SIG?**
0.000	0.00%	TRUE
0.000	0.39%	TRUE
0.000	0.00%	TRUE

Test	**P-Value**	**SIG?**
White-Noise?	0.00%	FALSE
Normal Distributed?	0.00%	FALSE
ARCH Effect?	0.00%	TRUE

DESCRIPTIVE STATISTICS (BUNKER PRICES – SINGAPORE)

Summary Statistics

Average:	386.9563
Standard Deviation:	145.4982
Skew:	0.29
Excess Kurtosis:	-1.16
Median:	363
Minimum:	146
Maximum:	696
1st Quartile:	258.5
3rd Quartile:	496

Significance Test		**5.00%**
Target	**P-Value**	**SIG?**
0.000	0.00%	TRUE
0.000	0.43%	TRUE
0.000	0.00%	TRUE

Test	**P-Value**	**SIG?**
White-Noise?	0.00%	FALSE
Normal Distributed?	0.00%	FALSE
ARCH Effect?	0.00%	TRUE

DESCRIPTIVE STATISTICS (BUNKER PRICES – MUNDRA)

Summary Statistics

Average:	417.0378
Standard Deviation:	145.3379
Skew:	0.29
Excess Kurtosis:	-1.16
Median:	393
Minimum:	176
Maximum:	726
1st Quartile:	288.5
3rd Quartile:	526

Significance Test		**5.00%**
Target	**P-Value**	**SIG?**
0.000	0.00%	TRUE
0.000	0.39%	TRUE
0.000	0.00%	TRUE

Test	**P-Value**	**SIG?**
White-Noise?	0.00%	FALSE
Normal Distributed?	0.00%	FALSE
ARCH Effect?	0.00%	TRUE

Year	MONTH	DATE	Fujairah	Singapore	Mundra
2013	1	1-Jan	616	620	650
2013	1	8-Jan	619	623	653
2013	1	15-Jan	617	621	651
2013	1	22-Jan	618	622	652
2013	1	29-Jan	620	624	654
2013	2	5-Feb	621	625	655
2013	2	12-Feb	635	639	669
2013	2	19-Feb	641	645	675
2013	2	26-Feb	631	635	665
2013	3	5-Mar	621	625	655
2013	3	12-Mar	617	621	651
2013	3	19-Mar	610	614	644
2013	3	26-Mar	603	607	637
2013	4	2-Apr	596	600	630
2013	4	9-Apr	598	602	632
2013	4	16-Apr	600	604	634
2013	4	23-Apr	605	609	639
2013	4	30-Apr	598	602	632
2013	5	7-May	601	605	635
2013	5	14-May	605	609	639
2013	5	21-May	606	610	640
2013	5	28-May	601	605	635
2013	6	4-Jun	599	603	633
2013	6	11-Jun	602	606	636
2013	6	18-Jun	598	602	632
2013	6	25-Jun	601	605	635
2013	7	2-Jul	606	610	640
2013	7	9-Jul	611	615	645
2013	7	16-Jul	614	618	648
2013	7	23-Jul	605	609	639
2013	7	30-Jul	601	605	635
2013	8	6-Aug	596	600	630
2013	8	13-Aug	600	604	634
2013	8	20-Aug	599	603	633
2013	8	27-Aug	601	605	635
2013	9	3-Sep	604	608	638

2013	9	10-Sep	602	606	636
2013	9	17-Sep	599	603	633
2013	9	24-Sep	603	607	637
2013	10	1-Oct	596	600	630
2013	10	8-Oct	602	606	636
2013	10	15-Oct	599	603	633
2013	10	22-Oct	595	599	629
2013	10	29-Oct	585	589	619
2013	11	5-Nov	591	595	625
2013	11	12-Nov	587	591	621
2013	11	19-Nov	589	593	623
2013	11	26-Nov	586	590	620
2013	12	3-Dec	585	589	619
2013	12	10-Dec	590	594	624
2013	12	17-Dec	586	590	620
2013	12	24-Dec	588	592	622
2013	12	31-Dec	587	591	621
2014	1	1-Jan	577	581	611
2014	1	8-Jan	570	574	604
2014	1	15-Jan	565	569	599
2014	1	22-Jan	571	575	605
2014	1	29-Jan	559	563	593
2014	2	5-Feb	556	560	590
2014	2	12-Feb	561	565	595
2014	2	19-Feb	564	568	598
2014	2	26-Feb	560	564	594
2014	3	5-Mar	561	565	595
2014	3	12-Mar	560	564	594
2014	3	19-Mar	553	557	587
2014	3	26-Mar	557	561	591
2014	4	2-Apr	554	558	588
2014	4	9-Apr	560	564	594
2014	4	16-Apr	558	562	592
2014	4	23-Apr	560	564	594
2014	4	30-Apr	550	554	584
2014	5	7-May	549	553	583
2014	5	14-May	552	556	586
2014	5	21-May	555	559	589

2014	5	28-May	554	558	588
2014	6	4-Jun	554	558	588
2014	6	11-Jun	560	564	594
2014	6	18-Jun	561	565	595
2014	6	25-Jun	583	587	617
2014	7	2-Jul	616	620	650
2014	7	9-Jul	613	617	647
2014	7	16-Jul	616	620	650
2014	7	23-Jul	611	615	645
2014	7	30-Jul	604	608	638
2014	8	6-Aug	596	600	630
2014	8	13-Aug	593	597	627
2014	8	20-Aug	588	592	622
2014	8	27-Aug	592	596	626
2014	9	3-Sep	585	589	619
2014	9	10-Sep	576	580	610
2014	9	17-Sep	575	579	609
2014	9	24-Sep	568	572	602
2014	10	1-Oct	571	575	605
2014	10	8-Oct	557	561	591
2014	10	15-Oct	545	549	579
2014	10	22-Oct	519	523	553
2014	10	29-Oct	508	512	542
2014	11	5-Nov	487	491	521
2014	11	12-Nov	474	478	508
2014	11	19-Nov	447	451	481
2014	11	26-Nov	435	439	469
2014	12	3-Dec	397	401	431
2014	12	10-Dec	381	385	415
2014	12	17-Dec	372	376	406
2014	12	24-Dec	356	360	390
2014	12	31-Dec	358	362	392
2015	1	1-Jan	266	270	300
2015	1	8-Jan	271	275	305
2015	1	15-Jan	274	278	308
2015	1	22-Jan	277	281	311
2015	1	29-Jan	271	275	305
2015	2	5-Feb	266	270	300

2015	2	12-Feb	285	289	319
2015	2	19-Feb	313	317	347
2015	2	26-Feb	319	323	353
2015	3	5-Mar	333	337	367
2015	3	12-Mar	346	350	380
2015	3	19-Mar	330	334	364
2015	3	26-Mar	315	319	349
2015	4	2-Apr	296	300	330
2015	4	9-Apr	316	320	350
2015	4	16-Apr	323	327	357
2015	4	23-Apr	334	338	368
2015	4	30-Apr	241	245	275
2015	5	7-May	346	350	380
2015	5	14-May	359	363	393
2015	5	21-May	370	374	404
2015	5	28-May	377	381	411
2015	6	4-Jun	386	390	420
2015	6	11-Jun	380	384	414
2015	6	18-Jun	368	372	402
2015	6	25-Jun	357	361	391
2015	7	2-Jul	346	350	380
2015	7	9-Jul	335	339	369
2015	7	16-Jul	308	312	342
2015	7	23-Jul	295	299	329
2015	7	30-Jul	281	285	315
2015	8	6-Aug	266	270	300
2015	8	13-Aug	257	261	291
2015	8	20-Aug	250	254	284
2015	8	27-Aug	236	240	270
2015	9	3-Sep	225	229	259
2015	9	10-Sep	233	237	267
2015	9	17-Sep	237	241	271
2015	9	24-Sep	243	247	277
2015	10	1-Oct	246	250	280
2015	10	8-Oct	244	248	278
2015	10	15-Oct	241	245	275
2015	10	22-Oct	242	246	276
2015	10	29-Oct	243	247	277

2015	11	5-Nov	241	245	275
2015	11	12-Nov	235	239	269
2015	11	19-Nov	228	232	262
2015	11	26-Nov	221	225	255
2015	12	3-Dec	216	220	250
2015	12	10-Dec	207	211	241
2015	12	17-Dec	197	201	231
2015	12	24-Dec	193	197	227
2015	12	31-Dec	176	180	210
2016	1	4-Jan	146	150	180
2016	1	11-Jan	151	155	185
2016	1	18-Jan	160	164	194
2016	1	25-Jan	163	167	197
2016	2	1-Feb	166.9	170.2	187
2016	2	8-Feb	160.1	161.4	185
2016	2	15-Feb	160.6	160.2	186
2016	2	22-Feb	158	152	186
2016	3	1-Mar	159.7	157.5	186
2016	3	8-Mar	176.2	178.1	186
2016	3	15-Mar	178.3	180.8	219
2016	3	22-Mar	177.8	184.6	237
2016	3	29-Mar	177.5	181.2	237
2016	4	5-Apr	174.8	175.8	237
2016	4	12-Apr	192.2	193.3	232.2
2016	4	19-Apr	193	195.1	227.9
2016	4	26-Apr	215.2	211.9	242.7
2016	5	3-May	222.6	218.6	254.9
2016	5	10-May	228.5	219.8	257
2016	5	17-May	245.1	229.5	278.4
2016	5	24-May	243.7	228.8	269.6
2016	5	31-May	243.3	230.2	266.5
2016	6	7-Jun	252.6	243.5	275.5
2016	6	14-Jun	240.6	236.6	279.5
2016	6	21-Jun	248	246	280.9
2016	6	28-Jun	253.2	250	271.6
2016	7	5-Jul	256.4	251.7	308
2016	7	12-Jul	252.4	246.5	293
2016	7	19-Jul	252.2	243.7	282

2016	7	26-Jul	234.8	228.2	270
2016	8	2-Aug	223.2	218.7	268
2016	8	9-Aug	235.5	226.5	268
2016	8	16-Aug	256.9	252.5	266.8
2016	8	23-Aug	262.1	258.3	264
2016	8	30-Aug	262.2	255.1	263.5
2016	9	6-Sep	266.1	258.5	277.9
2016	9	13-Sep	262.1	257.4	279.9
2016	9	20-Sep	265.5	257.9	278
2016	9	27-Sep	269.5	260.7	278
2016	10	4-Oct	281.3	273.7	278
2016	10	11-Oct	294.8	285.6	291.4
2016	10	18-Oct	293.6	287.9	312
2016	10	25-Oct	291.8	288.2	312
2016	11	1-Nov	277.3	275.1	309.6
2016	11	8-Nov	272.2	272.5	300.4
2016	11	15-Nov	268.1	249.5	302
2016	11	22-Nov	287.2	285.8	310.7
2016	11	29-Nov	297	296.5	316.5
2016	12	6-Dec	319.7	319.7	339.3
2016	12	13-Dec	327	331.3	351
2016	12	20-Dec	329.7	336.1	358.6
2016	12	27-Dec	334.2	322.4	359.2

YR: 2013- 2016			Fujairah	Singapore	Mundra
Mean			416.64	418.81	448.97
ST. Deviation			167.1213	168.9833	168.6402
MAX			641	645	675
MIN			146	150	180

Crude Oil Prices

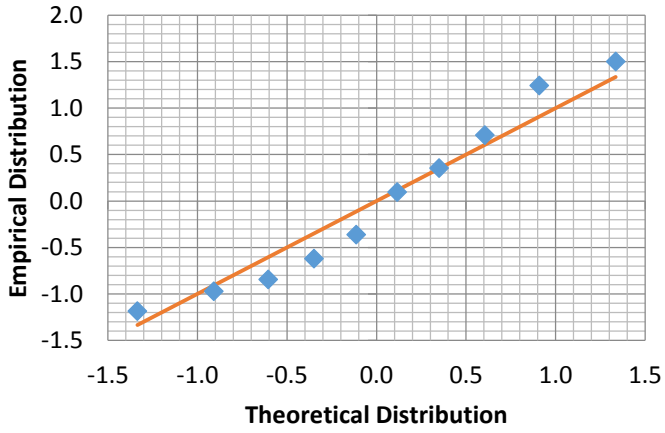
YEAR	BRENT	WTI
2005	54.52	56.59
2006	65.14	66.02
2007	72.39	72.20

2008	97.26	100.06
2009	61.67	61.92
2010	79.50	79.45
2011	111.26	95.04
2012	111.67	94.13
2013	108.66	97.99
2014	98.95	93.28
2015	52.39	48.71

Q – Q PLOT

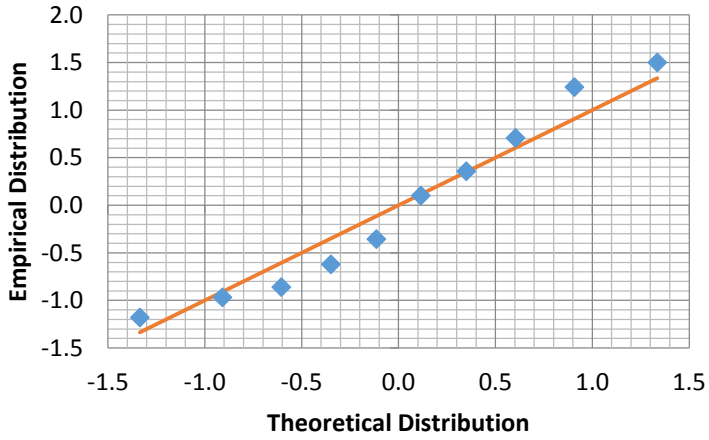
FUJAIRAH BUNKER

	Mean	STDEV
Q-Q Plot	383.7254	144.7671
Q	**Normal**	**Empirical**
9.1%	-1.3	-1.2
18.2%	-0.9	-1.0
27.3%	-0.6	-0.8
36.4%	-0.3	-0.6
45.5%	-0.1	-0.4
54.5%	0.1	0.1
63.6%	0.3	0.4
72.7%	0.6	0.7
81.8%	0.9	1.2
90.9%	1.3	1.5



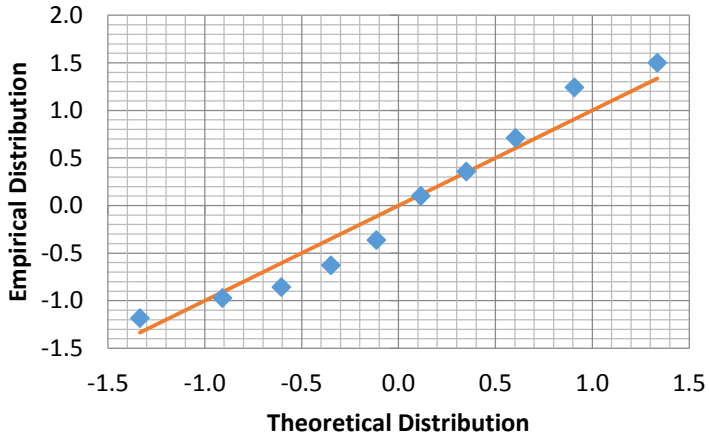
SINGAPORE BUNKER

	Mean	STDEV
Q-Q Plot	386.9563	145.4982
Q	**Normal**	**Empirical**
9.1%	-1.3	-1.2
18.2%	-0.9	-1.0
27.3%	-0.6	-0.9
36.4%	-0.3	-0.6
45.5%	-0.1	-0.4
54.5%	0.1	0.1
63.6%	0.3	0.4
72.7%	0.6	0.7
81.8%	0.9	1.2
90.9%	1.3	1.5



MUNDA BUNKER

	Mean	STDEV
Q-Q Plot	417.0378	145.3379
Q	**Normal**	**Empirical**
9.1%	-1.3	-1.2
18.2%	-0.9	-1.0
27.3%	-0.6	-0.9
36.4%	-0.3	-0.6
45.5%	-0.1	-0.4
54.5%	0.1	0.1
63.6%	0.3	0.4
72.7%	0.6	0.7
81.8%	0.9	1.2
90.9%	1.3	1.5



NORMALITY TEST RESULT

BUNKER PRICES - FUJAIRAH

Normality Test	Score	C.V.	P-Value	Pass?	5.0%
Jarque-Bera	34.75	5.99	0.0%	FALSE	
Shapiro-Wilk	0.94	#N/A	0.0%	FALSE	
Doornik Chi-Square	77.05	5.99	0.0%	FALSE	

BUNKER PRICES – SINGAPORE

Normality Test	Score	C.V.	P-Value	Pass?	5.0%
Jarque-Bera	34.99	5.99	0.0%	FALSE	
Shapiro-Wilk	0.94	#N/A	0.0%	FALSE	
Doornik Chi-Square	77.54	5.99	0.0%	FALSE	

BUNKER PRICES - MUNDRA

Normality Test	Score	C.V.	P-Value	Pass?	5.0%
Jarque-Bera	35.17	5.99	0.0%	FALSE	
Shapiro-Wilk	0.94	#N/A	0.0%	FALSE	
Doornik Chi-Square	78.39	5.99	0.0%	FALSE	

Web Sources

http://www.cockettgroup.com/wp-content/uploads/2009/10/Risk-Managment-Presentation.pdf

http://unctad.org/en/docs/dtltlb20092_en.pdf

http://www.cmegroup.com/trading/energy/refined-products/singapore-380cst-fuel-oil-platts-swap-futures.html

http://www.mabux.com/

http://shipandbunker.com/prices/apac/sea/sg-sin-singapore

https://www.riverlake.ch/en/r-c-publications/bunker-price.php?category=1048&year=2009&month=12

http://www.shipfinance.dk/media/1610/shipping-market-review-may-2016.pdf

http://www.shipfinance.dk/shipping-research/shipping-market-review/

https://www.google.co.in/search?q=World+GDP+Growth+(%25)&rlz=1C1CHZL_enIN738IN739&oq=World+GDP+Growth+(%25)&aqs=chrome..69i57j0l5.558j0j7&sourceid=chrome&ie=UTF-8

http://databank.worldbank.org/data/reports.aspx?source=2&series=NY.GDP.MKTP.KD.ZG&country=#

http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG

http://statisticstimes.com/economy/countries-by-projected-gdp-growth.php

https://www.google.co.in/webhp?sourceid=chrome-instant&rlz=1C1CHZL_enIN738IN739&ion=1&espv=2&ie=UTF-8#q=World+Merchandise+Export+Growth+(%25)&*

http://data.worldbank.org/indicator/TX.VAL.MRCH.CD.WT

http://data.worldbank.org/indicator/TX.VAL.MRCH.CD.WT

http://www.sciencedirect.com/science/article/pii/S2468013315300127

http://ac.els-cdn.com/S2468013315300127/1-s2.0-S2468013315300127-main.pdf?_tid=3ce3a57e-19eb-11e7-a119-00000aacb35d&acdnat=1491388558_772382376fb3e5c9aa6a83d450dd1e33

http://www.sciencedirect.com/science/article/pii/S2468013315300127

http://www.bath.ac.uk/e-journals/jtep/pdf/Volume_33_Part_2_185-207.pdf

http://www.martrans.org/documents/2009/prt/TRB_paper%2010_3188_Gkonis_Psaraftis_revised.pdf

https://www.researchgate.net/figure/281495086_fig2_Figure-5-Fuel-Consumption-by-Containership-Size-and-Speed

http://www.sname.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=ff43548b-fd62-4e5f-ac6e-be73b56ec473