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Recent Developments in Forward Freight Agreements: a Review

by

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Dedicated to four people who make me what I am

My parents, Abhijat Chahal and Atul Palkar

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Abstract

The size of the Forward Freight Agreements market for dry bulk shipping routes has seen a substantial increase in the past years. Though hit by the global sub-prime housing crisis, the trading volumes in 2010 are expected to double, compared to 2009 levels. This increase in volume of paper market could potentially influence the physical spot markets dynamics. This paper investigates the short term effects of FFA trading on Spot Markets in Dry Bulk shipping. This analysis aims to understand firstly if a relationship between the two markets exists and secondly, if it does, how do the two markets affect each other in terms of future movement.

Due to the confidentiality and anonymity as the basic principle of FFA trade, the availability of data is scarce. Hence the paper analyses the research question through the analysis of existing published research and its conclusions. The analysis is done following three important criterions: (a) cointegration relationship (b) causality relationship (c) predictability of spot rates using FFA prices. The cointegration relationship as the first step provides an indication if a relationship between the two markets is present or not. This is important since if no evidence of cointegration is found, then the FFA and the spot market would move independently and there would be no effect of one market on the other. The causality test helps to determine which market guides or causes the other market. In case of no unidirectional causality, this test helps to identify the extent the two markets affect each other. The predictability relationship is an indication of how well one market can predict the future outcome of the other market.

The results point to the existence of long-run cointegration between the spot and FFA markets. This, in conjunction with the causality relation, points to the fact that even though bi-directional causality is observed, generally the spot rates lead the FFA rates. Also an important observation is that since the FFA rates adjust to a greater extent to attain the long-run equilibrium than the spot rates, hence the FFA markets act as an important point for information assimilation. In one finding, it is also concluded that in periods of high volatility, spot rates lead the FFA rates while in periods of low volatility the FFA rates lead the spot rates. Tests for prediction of spot market movements using FFA highlight the fact that the FFA alone do not provide a good estimate for future spot prices. These when used in different models such as Vector Error Correction Model (VECM) in conjunction with past spot and FFA rates, the predictability of future spot prices is considerably improved. Thus in the short term, we observe that even though the FFA markets are important point for information assimilation, the leading role is played by the spot market and the FFA market adjusts to reach an equilibrium.

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List of Abbreviations

AR	Auto Regressive
ARCH	Auto Regressive Conditional Hetroskedasticity
ARIMA	Auto Regressive Integrated Moving Average
BCI	Baltic Capesize Index
BDI	Baltic Dry Index
BFI	Baltic Freight Index
BHMI	Baltic Handymax Index
BIFFEX	Baltic International Freight Futures Exchange
BPI	Baltic Panamax Index
BSI	Baltic Superamax Index
CAPM	Capital Asset Pricing Model
CFD	Contracts for difference
CML	Capital Market Line
ECM	Error Correction Model
ECT	Error Correction Term
FFA	Forward Freight Agreement
FFABA	Forward Freight Agreement Brokers Association
GARCH	General Auto Regressive Conditional Hetroskedasticity
I	Integrated
IMAREX	International Maritime Exchange
ISDA	International Swaps and Derivatives Association
LCH	London Clearing House
MA	Moving Average
NOS	Norwegian Futures and Options Clearing House
OTC	Over the counter
RW	Random Walk
SGX	Singapore Exchange Limited
SML	Security Market Line
VAR	Vector Autoregression
VECM	Vector Error Correction Model

Chapter 1 Introduction

1.1 Introduction

Dry bulk shipping plays a significant role in functioning of *global economies.* It transports goods such as coal, iron ore, grains, etc. over long distances at extremely low per ton-mile cost. In terms of total cargo carried, it accounts for about 38% volumes (Prokopczuk (2010), Bornozis (2006) and others) of the overall sea-borne trade.

With its international coverage and involvement of multiple players, the market for dry bulk shipping is fragmented. Also on the product end, providing a service of transportation of goods is almost similar for all ship-owners and ship-operators. Hence the dry bulk market exhibits characteristics of perfectly competitive market (Veenstra, 1999 p. 280) with many producers and consumers, all trading the same product (the product being transportation). Thus the producers (ship-owners and operators) do not hold any market power and are price takers. Also small cargo owners do not hold any ability to affect market prices.

The dry bulk shipping market with its reputation of being one of the riskiest businesses is often attributed for making enviable fortunes as well as unbelievable losses. This fact is emphasised by considering a snapshot of the barometer for freight rates of dry bulk shipping, the Baltic Dry Index (BDI). It demonstrated fluctuations amounting to a rise of 97% in 2002 while nose dive of 94% (Whittall, 2009) between May 2008 and December 2008. This exposes the market players to very high unpredictability in the freight rate outcomes and consequently to extreme freight rate volatility. Also since transportation is a derived industry, providing a service used by the commodity markets to move goods, the demand for shipping is dependent and influenced by the demand of the carried goods. This imposes on shipping additional volatility of the commodities markets too.

Due to the high uncertainty in earnings, owed to the resulting volatility and uncertainties in the freight market, the shipping industry has developed techniques to control this uncertainty and shift the risk to parties willing to accept it. This technique is referred as hedging. One of the instruments for such risk hedging is the Forward Freight Agreement (FFA) which has gained considerable importance over the years. This thesis is aimed at understanding the risks, the hedging techniques and use of FFA to safeguard from the freight rate risks.

1.2 Research Question

The introduction of futures market in 1975 (Ederington, 1979) marked the birth of financial hedging strategy. The businesses could now safeguard themselves from risks and also at times make profit by purchasing securities based on their expectations. The futures market over the years have evolved and become significantly important as hedging tool as well as for speculating purposes. Currently multiple sectors boast of a well developed and often an international futures market. To cite some: currency markets, metal markets, international oil futures and commodity futures market. These futures market often share some common basics such as physically storable underlier and cost of carry relationship (refer section 3.2). Thus the research carried out for such commodity futures in one market is often applicable to other markets too.

The advent of BIFFEX in 1985 marked an important milestone for the shipping industry. This was the first futures market for the shipping industry which was based on a service underlier. The players in shipping spot markets could now trade in paper market to hedge against freight risks from physical markets. Though, subsequently owed to the shortcomings of BIFFEX contract, mainly relating to its hedging efficiency, the BIFFEX was defunct in 2002 but the forward freight agreements, dealing in over the counter (OTC) trade, designed in

1992 by Clarkson Securities have enabled the continuation of the paper market in the shipping industry.

The FFA markets have proven to be a useful tool for shipping companies as well as cargo owners primarily for hedging freight rate risks. The volume of FFA's traded has increased substantially over the years. FFAs are contracts for difference (CFD) i.e. they are typically between two parties, buyer (long position) and seller (short position), with opposite market expectations and the contract stipulating that the buyer will pay the seller the amount difference of the contract price and the underlying price (or other way round as per the market movement). This provides the buyer as well as the seller stability in their future cash flows. Any fluctuations in the physical market can potentially be offset by the FFA market thus enabling the party to better plan their future cash flows. Generally in case of FFA markets for shipping, the ship-owner or operator is the seller and the cargo-owner is the buyer of FFA contract.

The second function of FFA markets is speculation. The FFA market generally faces a gap between the long and short position market players. This is where the speculators step in and fill the gap. The speculators do not hold hedging interest such as the ship-owner or the cargo owner and thus they freely shift between long and short position basis their expectations and profit incentive. This helps to fill the gap between the buyers and sellers in the FFA market. The speculators, eyeing to achieve profits, can bet on a position that could potentially yield them profitable returns. In a situation where their expectation of position is fulfilled the speculators could make profit otherwise they would undertake losses. Since, the absence of cost-of-carry relation makes it difficult to predict the forward contract pricing, preventing a possibility of commodity arbitrage, therefore the FFA market can potentially provide an opportunity for speculators to influence the market through expectations.

The third function which FFA market serves is owed to their information link with the spot market. The FFA market players purchase and sell contracts on the basis of their expectations of the future movement of market. This means that the FFA market reflects the expectations, which are in turn driven by the available information, of the market players. Hence the FFA market tends to be an important melting pot and assimilation point for new information. This expectation of the future, exhibited though the FFA rates, thus becomes a useful tool for the process of future price discovery. In case the effect of FFA market expectations becomes very strong, it could potentially play a role in directing future movement and setting prices for the spot market too.

The physical shipping market in the long run is governed by the principles of supply and demand with a long term equilibrium instrumented through adjustment of freight rates. In the short run this equilibrium can be subject to fluctuations caused by events such as shocks, inflationary deviations, political events, etc. Since "*financial asset returns are generally highly unpredictable over shorter horizons such as a day or a month"* (Melnick *et al*, 2008: p. 1832), and theoretically a relationship seems to exist between the spot and the FFA markets, this paper aims at answering the following questions:

- Identify the effects of FFA trading on spot market rates in the short term.
- Can FFA market be used for manipulating the spot market?

1.3 Relevance of the study

The FFA market for the dry bulk sector had grown from $56 billion in 2006 to $115 billion in 2007 (Bockmann, 2008). While it was expected to grow to $125 billion and exceed size of the physical market by 20% in 2008 (Bockmann, 2008) but due to global economic downturn the actual value observed an overall reduction. As per Freight Investor Service (FIS), the total market value for FFA trading for 2009 stood at $35 Billion and is expected to double in 2010 (McCarthy *et al*, 2010). Thus with a steady growing value of FFA markets, its effect on the spot market can be immense. This effect could be of considerable interest particularly market players and regulators.

The study of possible effects on the physical market will also be useful for furthering study of the price discovery function of FFA's. The market players would be able to better rely on FFA market prices and better predict the actual physical market outcomes using FFA trading. In respect to speculators as market players, their current share is limited and roughly estimated to amount to less than 10% (Bockmann, 2008). This has been attributed to high risks involved in the shipping derivative market, often claimed to be the world's riskiest derivative market. This study would aim at providing clarity for speculators towards understanding the FFA market. This should facilitate greater involvement of speculators and expanding the overall market size of FFA.

The implications of short term effects of FFA trading on the spot markets would hold equal importance for regulators too. It will provide a basis for further evaluation of stabilizing or destabilising effect of the FFA market and thus a basis for a decision to regulate or deregulate the FFA market. Also, in case of non-storable commodities, government intervention in spot market involves from the demand side (Kawai, 1983). In order to improve the market outcome, government is forced to buy the commodity, but due to its non storability, the commodity cannot be sold in future. By trading in the FFA market, the governments can buy the contracts in one period and sell them in another (demand or supply) without reducing the actual available commodity. This study will try to provide groundwork for developing further analysis of implications of government activity of trading in the FFA market.

1.4 Research methodology

The approach used for analysing the research question is literature review. The methodology involves, as the first step, extensive literature review aiming to identify the current researches undertaken in the field. This knowledge is then positioned into a broader frame work connecting the individual results with an objective to prepare them for better understanding and analysis. Finally the developed framework is used as the basis to analyse and synthesise the answer to the research questions.

In order to organise the literature review methodology a systematic structure, as suggested by Rugg *et al*, (2007 pp. 48-56), has been used. This approach helps for clarity in identification of relevant core literature and filtering out the associated literature, depending on their importance and relevance to the conducted study. Hence, in accordance to this approach, the study of literature has been carried out at four levels: *Seminal articles, Milestone articles, Straw man papers and example papers* and *Foundational article*.

Seminal articles refer to researches pioneering a new concept in the field. They are the articles which mark the introduction of a new concept and are the starting point for further works conducted.

Milestone articles are similar to seminal articles but for the fact that they mark the significant turn in a particular direction or where a particular advancement in the research occurs.

Straw man papers and example papers are the studies carried out for similar research question in same or other fields. Also they provide a cross-industry perspective to the problem addressed. They can provide suitable examples for supporting the *in question* study.

Foundation articles are the most important amongst the four segments. They form the core of the research by providing the concepts and results that are utilised as the starting point and often as the building blocks for the research. These concepts and results obtained are used as the basis for performing the intended research and as well as answer the research question.

1.5 Thesis structure

The thesis is divided into six chapters. The structure adopted can be described as funnel structure. This is to ensure a generic starting point thereby funnelling the content towards the objective of the thesis. Chapter 1 covers the introduction which focuses on familiarising the reader with the topic, its importance as well as the research methodology for the paper. Chapter 2 studies the risk analysis and quantification of risk in a business scenario. It then moves into applying this framework to a dry bulk shipping company. This if followed by understanding on the fundamentals of the freight market. Chapter 3 provides the core literature on the FFA markets. It covers the concepts governing the FFA market as well as the functioning of the FFA market. Chapter 4 identifies and summarizes the current literature available on the investigated topic. This section provides the foundation for understanding and relating the literature to each other firstly to prevent any overlap and secondly since the research methodology is literature review, this section is the foundation block for a comprehensive research solution. Chapter 5 performs the analysis. It uses the findings and studies of the literature and analyses them to find answer to the research question. Chapter 6 summarises the findings of chapter 5 in the form of conclusions while it also suggests potential further research that can be performed in extension to the one undertaken.

Chapter 2 Risk analysis in a dry bulk shipping company

2.1 Introduction

A bulk shipping company is a tramp service operator i.e. it does not follow any fixed route or schedule but operates in the region where it can find suitable employment opportunities. As the name suggests, it lends itself towards transportation of goods in large quantities over distances which often includes full shipload quantities. This makes the industry extremely fragmented where each player is capable to providing service with similar efficiency as other players in the market. The dry bulk shipping market is characterised by a market structure close to perfect competition (Veenstra, 1999 p. 280) with a large number of ship-owners and shippers where market players are price takers and where a well functioning second hand market exists that contributes to minimizing barriers to entry and exit. Therefore, it becomes important to understand the risks faced by a bulk shipping company. The chapter identifies risk quantification as the first step followed by the importance of risk management. This is important firstly to understand the importance of freight risk management and secondly the knowledge of quantification of risk is a critical basic for furthering the study of risk modelling as well as for analysing relationships between the two markets. Further it identifies the risks faced in a business and then in specific context to a dry bulk shipping company. The last section studies the dynamics of freight rate risk in the physical spot market as well as the factors affecting the freight rates.

2.2 Risk assessment

As per Rockafellar *et al*, (2002) the traditional outlook towards risk management was *single estimate* approach. This approach uses a single value for outcome of a project or a business activity. Hence, the risk appraisers identified specific *best estimates* numeric values to outcomes and hence contemplated the given scenario. Such appraisal techniques missed an important consideration of what was the risk involved in the situation and what is the confidence level of the calculated outcome.

In order to cater for risk or uncertainty, Kaplan *et al*, (1981) use a *set of triplet* approach. This is based on the fact that risk analysis has three components to it (Kaplan *et al*, 1981):

- What situation is likely to occur (i.e. what can go wrong)?
- What is the probability of this situation occurring?
- What will be the consequence of this situation going wrong?

These three components put together in the form of a set represent's a triplet. A set of exhaustive and mutually exclusive triplets set is what an analyst would always aim to achieve. This would include all possible outcomes with their probabilities and the expected outcome of each situation thus covering the complete risk portfolio.

A scenario analysis can be represented in the form of table known as a *pay-off matrix* below:

Table 1 Risk analysis: Scenario list

Scenario	Probability	Outcome
S_1	P_1	x_1
S_2	P_2	x_2
..	..	..
S_i	P_i	x_i
..	..	..
S_N	P_N	x_N

Where:

- S_i : Possible i^{th} scenario (identified)
- P_i : Probability of the i^{th} scenario occurring
- x_i : Consequence of the i^{th} scenario
- N : Total number of scenarios

Source: Author

In a practical situation, it is often quite difficult and expensive to identify all N possible scenarios and their outcome probabilities. In order to do so various techniques such market research, statistical data, expert's advice, mathematical modelling etc. are utilised. Though they do provide a rational outlook towards the possibilities of various situations in future but since the future is always dependent on many circumstances which are by nature unpredictable, hence these scenarios are embedded with certain degree of inherent uncertainty. Often the probability distribution is approximated using mathematical curves and instead of discontinuous steps a probability associated for each scenario, we achieve a continuous curve with the bell curve being the one of the most commonly used curve for such approximation. Also when the probability distribution corresponds to the probabilities of loss, they are called *loss distribution* (Harrington *et al*, 1999: p. 41).

The next step after obtaining the required details is to enable the use of these facts and figures in identification of risk. Though, in order to identify the risk involved, we must firstly know what to expect. The expectation outcome as defined by Rockafellar *et al*, (2002) can be found by calculating the weighted average of each outcome, weighed for its probability of occurrence. This in mathematical terms can be modelled as:

$$\bar{X} = \sum_{i=1}^{N} P_i * x_i \ldots (2.1)$$

$\bar{X}$= Expected outcome

The expected value of probability distribution provides information about where the outcomes tend to occur, on average. It must be highlighted at this stage that the expected value is an indication of the *possible* outcome and is a useful input for making decisions in the light of known information. The *realised* or *actual* outcomes do not necessarily coincide with the expected value. The expected value in case of calculating loss is known as *expected loss* (Harrington *et al*, 1999: p. 41).

As a measure of risk as variability around the expected value, the variance or standard deviation is the measure generally used. Though, sometimes other measures of risk are also used. For example, maximum probable loss within a certain confidence level, say 95% or in cases where it is required to measure the risk of large losses, measure of risk as the probability of an extreme outcome is used (Harrington *et al*, 1999: p. 44). In mathematical form, hence risk as variance or standard deviation can be represented as

$$Variance = \sum_{i=1}^{N} p_i (x_i - \bar{X})^2 \ldots (2.2)$$

$$Standard\ deviaition = \sqrt{\sum_{i=1}^{N} p_i (x_i - \bar{X})^2 \ldots (2.3)}$$

In case the standard deviation is zero, this would mean that the outcome is perfectly predictable and no other outcome other than that predicted will occur. In this case, thus the risk is nil since there are no variations to the prediction. As the standard deviation increases the outcome becomes more unpredictable. This is an indication that there exists a greater possibility of an outcome other than that which is expected and hence the risk in the given situation is greater. Thus standard deviation or variance is a commonly used measure of risk.

It could be pointed that the above risk assessment technique is strongly dependent upon how we quantify our measurements. Also, this could be contentious since when considering precedence's for making assessments for future how deep should we dig into the past. This difficulty is amplified in case of Greenfield projects, which do not hold any historical data to make predictions. It can be argued at this point that for such projects, scientific methods such as across sector information, market surveys etc. can be used as a helpful tool. This, in specific concern to dry bulk shipping company freight risk, will be discussed in the further course of text.

2.3 Business risk

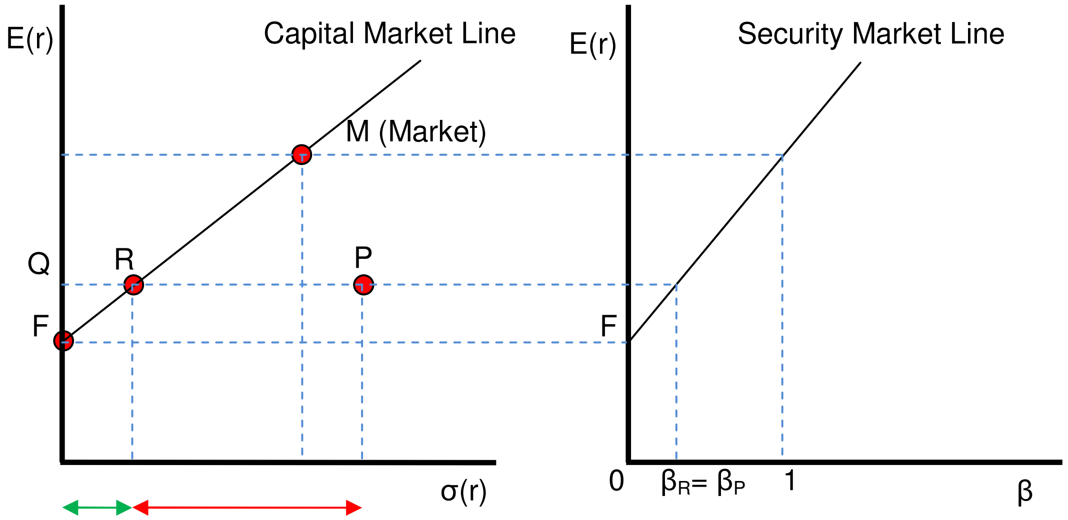
As per the modern financial theory, the primary objective of a business is to increase the wealth of its share holders or value maximization (Harrington *et al*, 1999: p. 18). Based on the risk appetite of the share holder, as per capital asset pricing model (CAPM), an investor can adjust her risk on a particular stock (Lintner, 1965). This risk can be separated into two components: (1) Market or systematic risk and (2) Business or non-systematic risk. Mathematically,

$$\sigma_P = \beta_P \sigma_M + Rest \ldots (2.4)$$

σ_P: Portfolio risk
σ_M: Market risk
$\beta_P \sigma_M$: Systematic risk (QR in figure)
$Rest$: Non-systematic risk (RP in figure)

Systematic risk, also known as aggregate or non-diversifiable risk, is the risk associated to the aggregate market returns. This, in simple terms can be defined as the basic level of risk faced in the given market for a specific level of expected returns. Systematic risk cannot be thwarted or reduced by diversifying the portfolio. Also it represents the minimum level of risk experienced by the market players. Typical examples of systematic risk as described by Van Horne (1980) are change in overall economy, tax reforms and change in world energy situation. In figure 1, for a portfolio represented by point P, the systematic risk is equal to QR. For a general scenario, the systematic risk level is the distance between the risk-free investment (F) and the capital market line (CML) for a given expected returns.

The second component of the overall risk experienced by an investor is the non-systematic risk. This component of risk is also known as specific risk, idiosyncratic risk, residual risk or diversifiable risk. Non-systematic risk is a risk that is specific to a particular company or a portfolio which the investor chooses to invest in. It is an additional risk which the investor undertakes over and above the systematic risk. Hence, as the name *'diversifiable risk'* suggest, it is the component of risk which can be significantly reduced by the diversification of portfolio. As per King (1966), the non-systematic risk constitutes almost 50 to 80 percent of the overall risk faced by market players. Some examples of systematic risk as suggested by Van Horne (1980) includes a wildcat strike affecting only one company, a new competitor who begins to produce essentially the same product and a technological breakthrough that makes the existing product obsolete. In the figure 1, RP represents the non-systematic risk for the portfolio P.



$$E(r_p) = r_f + [E(r_M - r_f] * \left(\frac{\sigma_{r(p)}}{\sigma_{r(M)}}\right) * \rho(r_p, r_M)$$

$$E(r_p) = r_f + [E(r_M - r_f] * \beta_p$$

Figure 1 CAPM CML (Capital Market Line) and SML (Security Market Line)

Source: Brealey *et al*,(2007)

In order to reap a return equal to Q (refer figure 1), an investor can invest in any portfolio lying on the line QRP. As can be seen from the figure, QR is the systematic risk, which means that no combination of stocks and shares can lead to a portfolio with risk lower than the systematic risk. Therefore, the portfolio, in the given market scenario, cannot lie on the section QR. Moving on, as we move from R towards P, we encounter a growing level of risk. The lowest risk is observed at point R equal to systematic risk, while as we move towards P, the risk increases. This component of risk is the non-systematic risk.

An important observation at this stage is that with a movement along the RP portfolio line leads to an increase in risk, but no change in β (measure of systematic risk). This in terms of investor's perspective means that an increase in non-systematic risk does not yield her any increase in expected returns. This is also observable in equation 2.5. Thus the portfolio R is known as the efficient portfolio, yielding maximum returns for a given risk level, while P is known as an in-efficient portfolio. Thus ideally the investor will choose the portfolio R instead of P.

$$E(r_p) = r_f + [E(r_M - r_f] * \beta_p \ldots (2.5)$$

$E(r_p)$: Expected rate of return on portfolio
r_f: Risk free rate of return
r_M: Efficient market rate of return
β_p: Measure of systematic risk for portfolio

Non-systematic risk, as identified above, is a diversifiable risk and as per Bettis (1983), various studies show that non-systematic risk can be sufficiently eliminated by even a random selection of 15-20 stocks. Thus this ability to minimise the overall non-systematic risk simply by diversification makes it un-interesting for the investors and hence it does not reflect in the valuation of the firm (according to modern financial theory) (Bettis, 1983). This leads to the conclusion, as per CAPM, that the managers must not concern themselves with managing of non-systematic risk because such behaviour will not be rewarded in the stock market (Bettis, 1983). Then why should the managers look at reducing non-systematic company specific risks?

In order to appreciate why firms divert their scarce resources towards management of non-systematic risk we need to look into the competitive strategy (Raphael *et al*, 1990). As per Bettis (1983), strategic adaptation by skilful, rigorous and continuous management of non-systematic risks lies at the heart of the company's strategic management. Strategic management is the process through which managers ensure long term survival and growth of the firm (Chakravarthy, 1982) and hence it has been central cause for organisational development determining if the organisation would survive and grow or decline and perish (Bettis, 1983). A converging point is brought in by Raphael *et al*, (1990) identifying that the reduction of business risk allows the firm to acquire factors of production at lower cost, to operate more efficiently or both. This is consistent with the value maximisation and efficient capital market theory (Raphael *et al*, 1990) that says that the firms will aim to maximise the value for its shareholders.

2.4 Types of business risks

With the understanding of importance of risk identification and quantification, this section develops the risk framework for a dry bulk shipping company. This is important for the understanding the importance of freight rate risk management against the other riskes faced by the company.

In the next step, post understanding the requirement for risk management, is to describe the various risks faced by a business firm. This poises specific difficulty for two aspects: firstly each firm is unique and secondly it is extremely difficult to identify all the possible risks that a firm can face. Hence in order to understand the risks faced by a firm, Harrington *et al*, (1999 pp. 4-5) identifies the risks faced from the perspective of variation of cash flows and business value. They identify the risks as three major risks as: price risk, credit risk and pure risk.

A firm is always exposed to the risk of variation of the prices of the inputs of its factors of production of goods and services as well as the price it can command for its output in the market. This risk is classified as price risk. The specific types of price risks are commodity *price risk, exchange rate risk* and *interest rate risk* (Harrington *et al*, 1999: p. 4). On the input side, price risk refers to the changes in the cost of raw materials, labour costs, equipment and machinery etc. while on the output price risk is the central theme of strategic risk management including the analysis of sale and purchase of existing and future products and services (Harrington *et al*, 1999: p. 4). The price risk associates with operations in an international environment, sourcing inputs and output to and from different sources, increases the price risk due to various factors such as difference in legal jurisdiction, etc.

In course of day to day business, a firm often lends out or is given a credit in terms of delayed payments as accounts receivable. This can be as simple as a credit period provided by a company to a customer for payment of the goods delivered to something as a credit lent out by a bank to its customer. The credit risk is the risk faced by the firm in situations when the counter party fails to make the promised payments. This risk is particularly large for big commercial banks (Harrington *et al*, 1999: p. 5) which are subject to load defaults from their borrowers. In case this risk is substantial, the firm would not be able to service its debts and could even be forced into bankruptcy. While on the credit markets, it would be forced to pay higher interest rates for the credit it raises in situations of high credit risk.

Credit risk can be further classified into three types (Alizadeh *et al*, 2009: p. 400):

> *Default risk*: Failure of the counterparty to completely or partially fulfil its contractual obligation
> *Downgrade risk*: Financial loss to the party due to downgrading of the counter party's credit status, by credit-rating agencies, leading to reduction in value of contracts such

as loans that are drawn or bonds issued by counter party. This does not automatically mean that the counter party will default.
Credit-spread risk: This refers to the change in yield premium of a debt obligation or an instrument (bond or loan) due to change in market conditions.

Pure risk is the biggest component of risk which the traditional management focused on. They include risks such as reduction of valuation of firm due damage to assets, legal liability for damage or harm to customer, shareholders or other parties, worker injuries, employee benefits etc. (Harrington *et al*, 1999: p. 5).

2.5 Risks in a dry bulk shipping company

The risks of a dry bulk shipping company can be identified broadly using the previously explained frame work. To elaborate on the specific application of this framework onto shipping industry, Alizadeh *et al*, (2009 pp. 3-6) is a useful guide. The following section provides an application of this framework to a shipping company while identifying the risks it faces.

2.5.1 Price risk

The price risk refers to the risk a business is exposed to, due to the variation of its input and output prices. In the specific application to a shipping company, the primary output of this business is a service i.e. transportation of goods, while in order to provide this output it utilises various inputs such as bunkers, crew, ships, brokers, staff etc. At this point it can be argued that for certain ship-owners, large profits are obtained through inter-temporal arbitrage of sale and purchase of ships. This could lead to an inference that sale and purchase of ship can also be defined as an output of a shipping company. This can be an important constraint and depending upon the situation it could feature as an input cost or an output price. For the purpose of the study we exclude such gains as well as losses as inputs/outputs and only consider the price risk due to exposure to the variation in output and input costs. As per Alizadeh *et al*, (2009 pp. 4-5) the four most important sources of price risk are: freight rate risks, operating cost risk, credit risk and asset price risk.

Freight rate risk: The importance of freight rate risk can be better highlighted with a brief discussion of the four shipping markets. As per Stopford (1997), a ship-owner is trading in four shipping markets which trade different commodities: (a) the freight market where she trades sea transport, (b) sale and purchase market where she trades second hand ships, (c) the new-building market where she trades new ships and (d) the demolition market where she deals with recycling and dismantling of old ships (refer figure 2). The main cash inflow, for the shipping industry, is the freight revenue and the other source of cash inflow is the demolition market (Stopford, 1997 p. 79). Therefore, the variation of the freight rates can severely impact the cash-flows of a shipping company which, in difficult periods, can mark the difference between survival and bankruptcy. The understanding of the freight market is an important foundation towards analysing the forward freight market. Section 2.6 will detail further into the fundamentals of freight determination and factors affecting the physical markets.

Operating cost risk: The direct and indirect costs of running the ship can be associated to the input costs. When determining profits, freight rate volatility describes the earning potential of a company while operating costs volatility defines the overall cost level. Thus by setting the bottom line for a company, it plays a pivotal role in defining the profit margins which a shipping company can expect to reap. This also means that high volatility of the operating costs can have severe impacts on the profit margins of the company. In the specific context of operating cost risk, bunker rates volatility, which account for more than 50 percent of total voyage expenses (Alizadeh *et al*, 2009: p. 3), is of particular important. The bunker prices

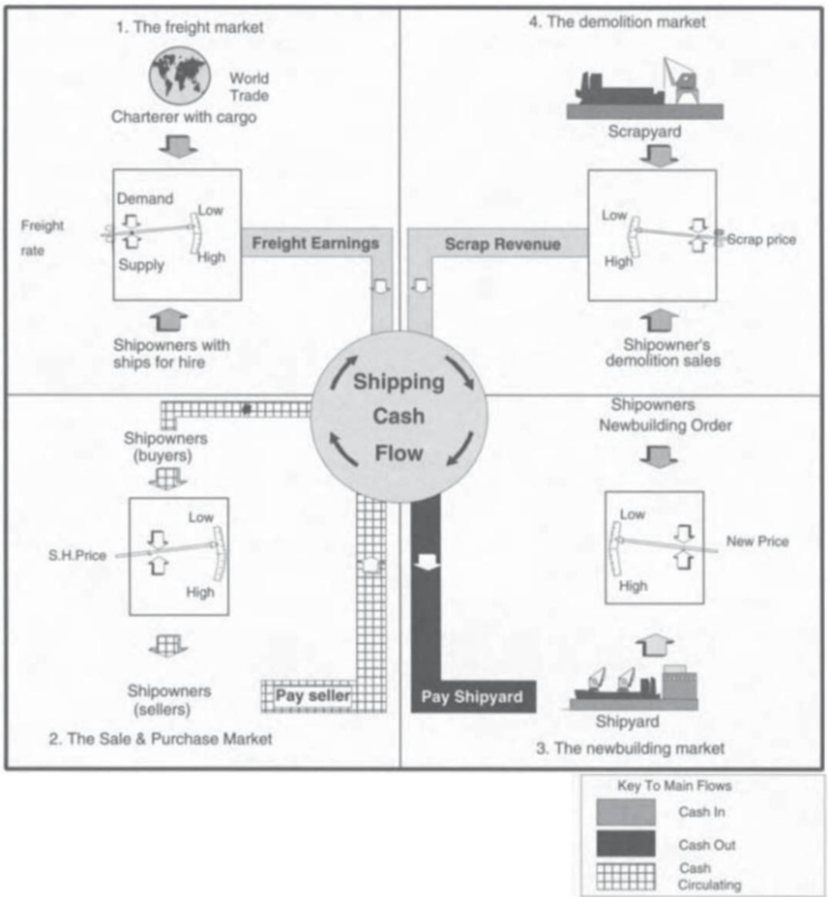


Figure 2 Four Shipping markets

Source: Stopford (1997 p. 80)

are directly related to the world oil prices which are intrinsically subject to high volatility. The importance of bunker rate volatility can be highlighted with an example of the bunker prices volatility in 2008 which led to bunker price rising up by almost 260% (Transpacific Stabilization Agreement, 2008). Thus it is important for the ship-owners and operators to ensure operating cost stability for sustainable operations.

Interest rate risk: This type of risk can be segmented into two risks faced by a shipping company: firstly, earnings in US dollars while expenditure in local currency exposes them to exchange rate risk and secondly the variation in interest rate for loans at floating rates. For example, the capital intensive nature of a shipping company requires it to loan capital for financing. This loan is borrowed in local currency as a means of financing sale and purchase which are at floating rates. While for repayment they are exposed to exchange rate risk for repaying local currency loans using US denominated freight income.

Asset price risk: For a shipping company valuation, the main asset comprises of its ships. This can be seen from the fact that many loans taken by a shipping company use ships as an asset. In case the value of the ship varies it can lead to volatility in the value of the company. Besides affecting the overall balance sheet, since many shipping loans use ships as collateral, thus asset price risk also affects the ability of the company to raise loans due to change of its creditworthiness. Thus often ship-owners, ship-operators as well as bankers monitor ship-price volatility and incorporate such information in their lending and investment decision (Alizadeh *et al*, 2009: p. 4).

2.5.2 Credit risk

Credit risk or counter party risk is possibility of loss occurring due to a situation where the counter party fails to make the promised payments. This includes the risk of counter party not performing its contractual obligation in terms of the financial amount as well as not respecting the contractual timing of the payment. Therefore a company with large credit obligations and with many debtors whose credit records are not well known to the company is vulnerable to a greater credit risk.

From the shipping company's point of view, besides basic business counter party risks, the reasons for credit risk can be attributed to four main factors. Firstly due to the spread of business and scope of shipping, it is often difficult to identify the creditworthiness of counter party which could be located across the globe and following a different (local) legal and financial framework. Secondly due to the fragmented nature of bulk shipping (direct players as well as their suppliers) there exist multiple parties. This leads to the difficulty of lack of transparency of cash flow records of all the counter parties. Often the performance of contracts is based on trust. Thirdly, in shipping most of the contracts are principal to principal contracts. This means that the two parties agree to do business with each other and rely on others ability to honour the agreement (Alizadeh *et al*, 2009: p. 399). This exposes each party to credit risk of other party's failure to honour the contractual obligations. Fourthly, shipping by the innate structure is a risky business and agents involved are subject to volatile markets. Hence it is always a possibility that agent might not be able to fulfil the obligations.

2.5.3 Pure risk

As described in 2.4, pure risks include risks such as reduction of valuation of firm due damage to assets, legal liability for damage or harm to customer, shareholders or other parties, worker injuries, employee benefits etc. (Harrington *et al*, 1999: p. 5). Thus for shipping company's point of view, they could include liabilities and costs incurring due to damage of vessels, accidents, damage of shore facilities, personnel injuries etc. This covers losses which could occur due to physical risks, technical risks and human error as well as the risk of legal liability (Alizadeh *et al*, 2009: p. 5).

2.6 Freight rate determination

Freight rates in shipping are extremely volatile and exhibit large fluctuations. Therefore in order to understand the dynamics of freight rate risk, it becomes important to appreciate the factors determining the freight rates. The shipping supply and demand model has been detailed by Stopford (1997), therefore the following section only briefly looks into the demand for ocean transportation services, the supply of tonnage and thereafter the combination of the two in order to understand the dynamics of freight rate changes. This includes the interaction of the four shipping markets (Stopford, 1997 pp. 77-81) which constitute the supply side of the transportation service while on the demand side it details on the derived nature of the transportation activity.

2.6.1 Demand for shipping

The demand for commercial shipping is a derived demand (Rodrigue, 2010). This means that the demand for shipping is derived from the demand of other goods. This in effect has two main implications with second resulting from the first. Firstly shipping, in isolation, is not a desired service and cannot be sold as a product such as travel and tourism. This can be owed to the fact that unlike production, packaging, labelling etc shipping does not intrinsically add value to the end product but it relies on the possibility to arbitrage between production and consumption centres. Secondly, since the demand for shipping is a derived demand, its demand closely follows the activity level in other sectors. Thus a change in price of the related goods and services has a direct impact on the demand for shipping.

The demand for shipping is a result of combination of multiple factors acting together. Stopford (1997 p. 114) identifies five main factors which are important in defining and predicting the dynamics of shipping demand: the world economy, seaborne commodity trades, average haul, political events and transportation costs.

This sourcing is captured by measurement of the world economic activity. The derived nature of demand of shipping is based on sourcing of goods and commodities from different regions. Since most of the production and consumption, basis ton-mile[1], are routed through ocean. Therefore, the world economy is one of the most important factors for the demand for shipping.

2.6.2 Supply of shipping capacity

The four shipping markets (Stopford, 1997 pp. 78-81) consist of the freight market, sale and purchase market, the new-building market and the demolition market. These markets, driven by profit objective, tend to move together in relation to each other as a result of interaction between various market players.

In order to understand the dynamics of the four markets, let us assume a scenario of increasing demand for transportation. This leads to an increase in the demand for ships and consequently an increase in the freight rates for the freight market. This has an effect on the new-building market where increased demand leads to ship-owners ordering new ships. Simultaneously, the scrap market observes a reduction in the scrapping levels. This is attributed to the fact that the previously un-profitable old ships can now be operated, in the light of the new higher freight rates, as profitable vessels. In the second hand market, the activity level increases since buyers are willing to pay higher prices to own a vessel immediately and make profit from the increased freight rates. Also any vessels in layup are now taken into operation to meet the increased demand for shipping.

Thereafter, even with all vessels employed, when the shipping demand further increases then an increase in the effective supply is observed. This is done by using methods such as increase in speed of ships, delay in repair and maintenance schedules, deferring dry docks etc. Thus the supply of ton-mile of ships is increased by increasing productivity of ships.

In the long run, during the next stage the previously ordered new-deliveries start arriving. Thus, now the physical supply of ships increases and based on the demand and supply principles, the freight rates are pushed down. This leads to ship-owners operating at marginal costs and unprofitably. At this stage, the new-building orders reduce drastically. In the second hand markets, the sale and purchase activity is significantly reduced due to the low prices and surplus ship availability. This period also observes a reduction in ship speed slow steaming and vessel lay-up.

[1] Ton-mile is a measure of freight transportation using the tons of cargo carried over miles of distance

Once the freight rates are lowered sufficiently, below the marginal operating cost, the ships are moved into lay-up. The scrapping activity increases substantially since the older ships become unprofitable to operate now. The companies could run into cash-flow difficulties and sell the ships to stay solvent. At this stage the supply of ships starts to adjust to the demand for ships

The reduction in the overall supply of ships leads to improvement of freight rates. These improvement in freight rates lead to the first step of the cycle as explained above.

2.6.3 Freight rates

The freight rates are determined by equating supply with demand. It must be noted that, since the physical supply of ships is fixed and restricted by the number of ships, thus in the short run the supply curve is elastic up to the point of employment of all ships. Once this point is reached, the supply curve becomes very inelastic with increase in ton-mile possible

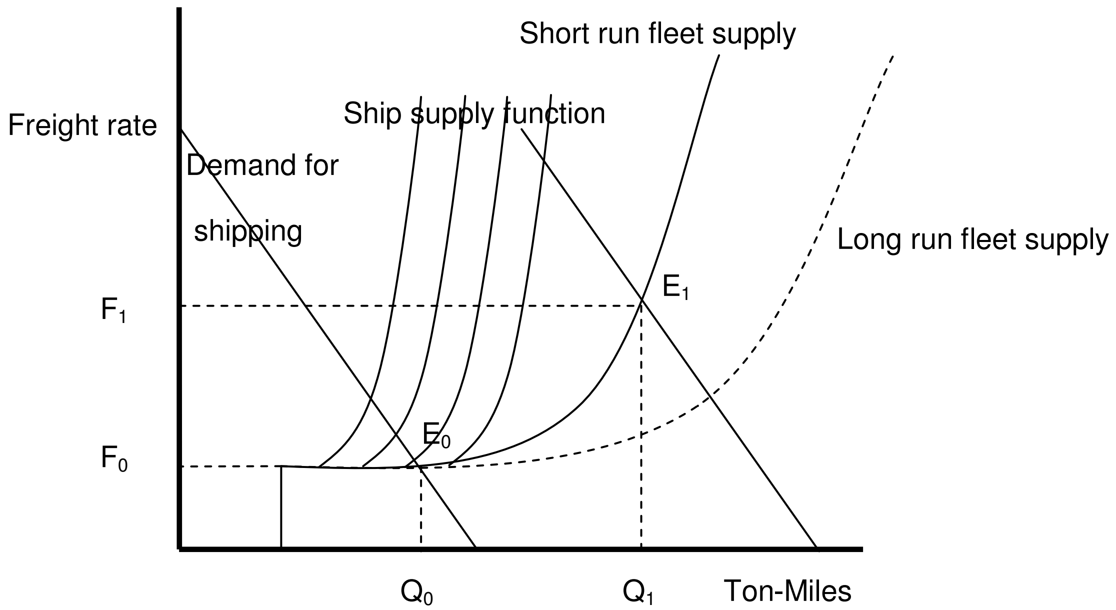


Figure 3 Shipping supply and demand function

Source: Stopford (1997 p. 140)

only by increase in the productivity of the ships.

The freight rate determination curve can be seen in figure 4. We observe that the initial increase of demand i.e. when the curve moves from E_0 towards E_1, the freight rates do not change much. This is the period when the fleet supply is adjusting to the demand. During this period, as seen in the figure, the ship supply curve refers to the ton-mile capacity of individual ships. The left most curve represents the most efficient ships which are the first to be employed and as the demand increases, less efficient ships are also taken into active service. Thus the fleet supply curve is an aggregate of the ship supply curve.

Subsequently, as the demand increases further, due to the inelasticity of the fleet supply curve, the freight rates observe a drastic increase. This region is characterised by increase in the productivity of the fleet. Eventually, in the long run, when the demand equates to supply, the availability of new capacity reduces the freight rates at similar levels similar to those attained previously.

Chapter 3 Forward Freight Agreement (FFA) market

3.1 Introduction

The discussion in the previous chapter emphasises on the fact that the freight rates are an outcome of the equilibrium of the ton-mile demand for cargo carrying capacity and the effective supply of ships. This relation holds true in the long run (a period during which physical ship supply can increase, due to new building, to match demand). Though in the short run (when the physical ship supply remains unchanged), the freight rates and the equilibrium is affected by many factors. These could include financial shocks, expectations, unveiling of new information etc. The FFA market is gaining importance in protecting and hedging the market players from these short term variations. This chapter explains the fundamentals of FFA markets. It covers the following section describes the FFA market and provides an example to understand the basic hedging strategy achieved through FFA trade.

3.2 Derivative market

An FFA, as defined by Angelidis *et al*, (2008), "*is an over the counter agreement between two principals that set a freight rate for a specified volume cargo and a vessel type on certain routes at a date in the future".* These contracts are pure paper trade which do not involve any actual ships or cargoes. Thus due to the absence of any underlying physical commodity, the FFA contracts are unlike the other derivative markets.

3.2.1 Commodity derivatives market

For commodity markets the physical and the derivatives markets are linked with the *cost of carrying principle* (Holbrook (1949), Heaney (1998), Kawaller *et al*, (1987) etc.). This means, assuming no profit, the price of the forward agreement must be equal to the sum of present value of the underlying commodity and the cost of holding it up to the expiry date of the contract. This can be modelled mathematically and be expressed as follows (Alizadeh *et al*, 2009: p. 19)

$$F(t,T) = S_t e^{(r+c-y)(T-t)} \dots (3.1)$$

F(t,T): Value of forward agreement today, maturing at T
S_t: Current value of commodity today
r: Interest rate costs
c: Storage costs
y: Eventual convenience yield
T: Maturity date of the futures contract
t: Duration of futures contract

The two markets are linked through arbitrage. In case the yields of futures contract is greater than the actual cost of holding the commodity up to the maturity period, market players will arbitrage by purchase the futures contract. This increased demand would eventually lead to a fall in the valuation of the futures yields and hence correction of its value to a normal level. In case of a lower yield on futures contract reverse-arbitrage occurs. Hence we observe that the two markets are strongly linked through the process of arbitrage.

3.2.2 Shipping derivatives market

The scenario changes in case of shipping due to the presence of a non-storable underlying (seaborne transportation) service instead of a storable physical commodity. In this case, the relation between the futures and the current price as developed by Working (1970) (as reprinted in Working (1977)) for storable commodities need not be applicable due to the absence of holding cost. Studies for such relationship between non-storable commodity and their futures have been carried out by Eydeland (1998), A. Eydeland *et al*, (2001) and Bessembinder *et al*, (2002) (as cited in Kavussanos *et al*, (2004*b* p. 274)) in the electricity derivates market.

The absence of cost of carrying relationship leads to the two markets being associated through expectations of market players. This may cause the relation between the two markets, in case of non-storable commodities, to be weaker than that in case of storable commodities. Thus the impact of FFA on the spot market rates may not be as strong as that in case of storable commodities Kavussanos *et al*, (2003 p. 205). Mathematically, the two markets can be related as (Alizadeh *et al*, 2009: p. 19)

$$F(t,T) = E(S_T \mid \Omega_t) \ldots (3.2)$$

F(t,T): Value of forward agreement today, maturing at T
$E(.\mid.)$: Mathematical conditional expectations operator at time t
Ω_t: Information set available to market participants at the same time conditional to which expectations are calculated
S_T: Current value of commodity today
T: Maturity date of the futures contract
t: Duration of futures contract

3.3 Long and short position

The FFA market, as any other market, is constituted by buyers as well as sellers. The buyer of an FFA would try to hedge herself from the potential rise in cost of transportation of her goods in future. Therefore, the buyer of FFA contact expects that the markets will move upwards and in order to hedge herself from this rise, she purchases the FFA contract. The purchase of derivative contract by the buyer is known as *long position* or *long forward*. In case of hedgers, a buyer would generally be the cargo owner intending to ensure stability in the future cost of transportation of her goods. The payoff for long forward can be given as follows (Chance *et al*, 2008: p. 185)

$$P_S = N_S\,(S_0 - S_T) \ldots (3.3)$$

P_S: Payoff for short position
N_S : Number of short position forward contracts
S_T : Final price of underlier
S_0 : Set/agreed price of underlier

While on the other hand is a seller of FFA contact. This party holds the opposite expectation than that held by the buyer or long position party. The seller expects the future conditions to develop such that the overall freight rates of the vessel will drop. This would lead to a reduction in overall earnings of the seller. Therefore in order to protect herself from the effects of reduced freight rates, she will sell FFA contracts. A seller of derivative contract takes a *short position* or *short forward*. In case of hedgers, the short position would be undertaken by the ship-owner or ship-operator intending to protect them from the effects of a reduction in future freight rates. The payoff for short forward can be given as follows (Chance *et al*, 2008: p. 185)

$$P_L = N_L\,(S_T - S_0) \ldots (3.4)$$

P_L: Payoff for long position
N_L : Number of long position forward contracts

S_T : Final price of underlier
S_0 : Set/agreed price of underlier

From equations 3.3 and 3.4, we observe that the payoff's for short and the long position for an equal number of shares is equal, but mathematically opposite in sign. This means that the gains of long position are received by an equal corresponding loss in the short position. This implies that the FFA market is a zero sum market with the gains for one party balanced by losses for the other party. This can be mathematically denoted as

$$P_S - P_L = 0 \ldots (3.5)$$

P_S: Payoff for short position
P_L: Payoff for long position

Using equations 3.3 and 3.4 we can plot the payoffs for the short and long position respectively (refer figure 4). It can be seen that the gain in the corresponding payoffs in the long and positions are equal but a gain in one market is paid off by the loss in the other.

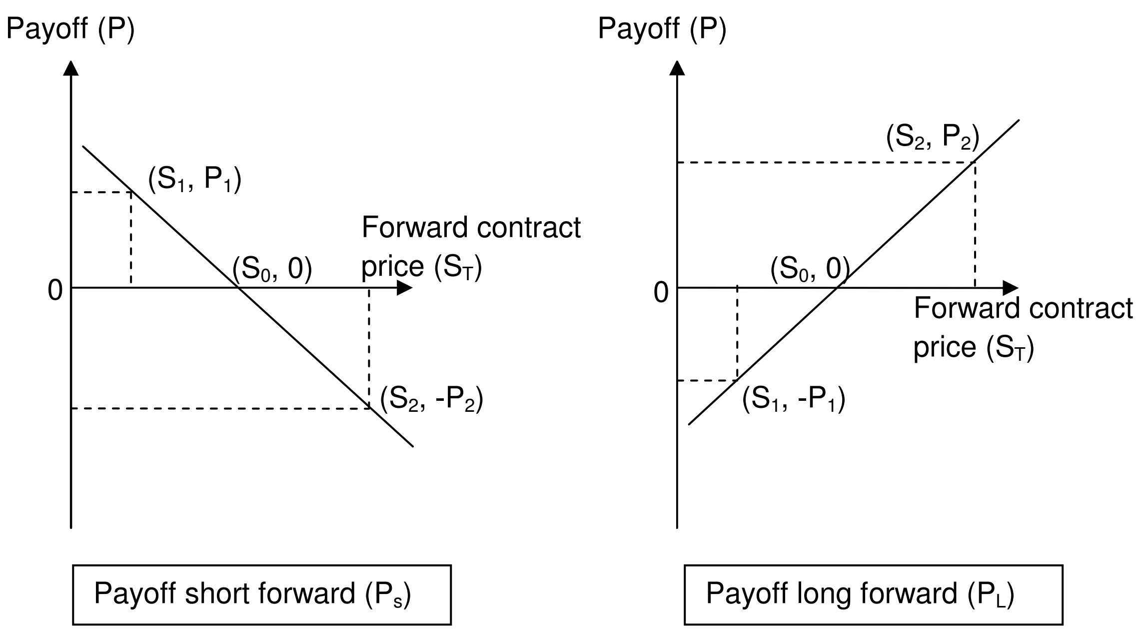


Figure 4 Payoff for Long and Short forward

Source: Adapted from Chance *et al*, (2008 p. 186)

(Whaley, 2006). This total number of contracts outstanding (long or short) is known as *open interest*. The total number of contracts outstanding can be broken down into hedgers and speculators (refer figure 5). In this case, it is observed that the number of outstanding contracts for hedgin in the short position exceeds the number of outstanding contracts for long position for hedging. This can be considered to be indicative of the fact that the hedgers expect the underlying asset (refer section 3.4) to fall in value and hence more players are intending to protect to hedge themselves from the effects by selling the contracts. Another important observation from this graph is that the gap between hedgers willing to take long and those willing to take short position is filled by the speculators. This breakdown of the open interest between hedgers and speculators varies with time and the underlier.

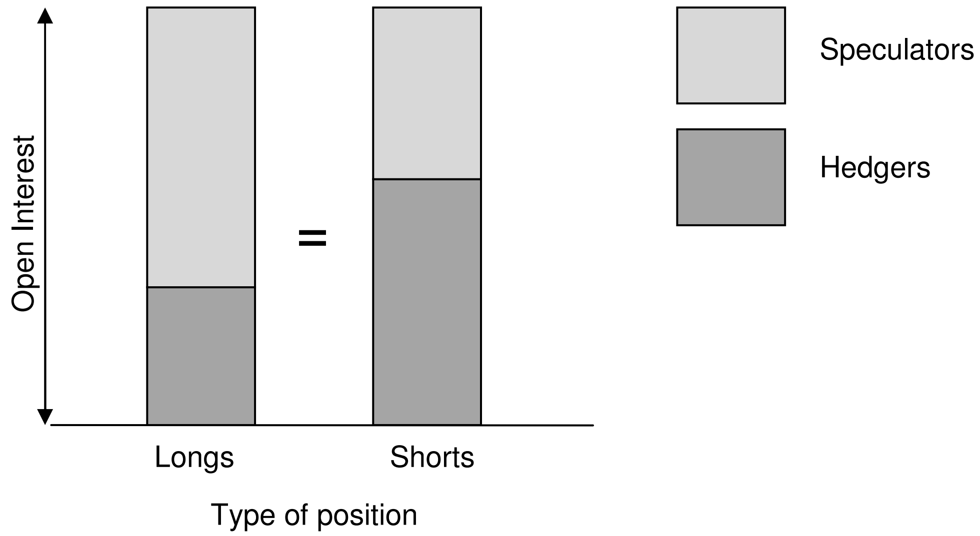


Figure 5 Breakdown of Open interest between Hedgers and Speculators

Source: Whaley (2006, p. 7)

3.4 Underlier

In order to trade a derivative of any non-storable commodity, it is important to have reliable information for the price of the underlying commodity. Since the FFA holds this characteristic, of non-storability, therefore to obtain reliable information of the freight levels it uses index as an underlying. The most commonly used indexes are the indexes published by the Baltic exchange, though depending on the agreement, the underlying index could vary, e.g. Platts in tanker sector. This makes it important to understand the underlying index prior to detailing on the FFA market. Since there exist many literature on this subject (e.g. Alizadeh *et al*, (2009), Kavussanos *et al*, (2006), Denning *et al*, (1994) etc.) thus only the basic information of the Baltic Exchange and the indexes has been covered.

Baltic exchange, based in London, is an independent source of information on the maritime industry. Its members are market players who are involved in various sectors of shipping industry and involved in the majority of ship fixtures as well as second hand market dealings. The Baltic exchange launched the BIFFEX (Baltic International Freight Futures Exchange) in 1985 and pioneered the paper trade in the shipping industry. The underlying index for the BIFFEX contract was the Baltic Freight Index (BFI). It initially consisted of 13 voyage routes and variety of cargo varying from 14,000 metric tons (mt) of fertilisers to 120,000 mt of coal. In 2002 BIFFEX was discontinued due to low trading volumes. Also the BFI was subsequently refined to meet the segmentation of the dry bulk shipping. The BFI was sub-divided into further markets in order to better track market developments (Kavussanos *et al*, 2006 p. 235). The resulting indexes were the Baltic Panamax Index (BPI) in 1998, Baltic Cape Size Index (BCI) in 1999, Baltic Handymax Index (BHMI) in 2000 and Baltic Superamax Index (BSI) formed in 2005 (Kavussanos *et al*, 2006).

Table 2 Baltic Panamax Index route definitions

Route	Description	Weighting
P1A_03	Delivery Skaw–Gibraltar range for a trans-Atlantic round voyage (including ECSA), redelivery Skaw- Gibraltar range. Duration 45–60 days	25%
P2A_03	Delivery Skaw–Gibraltar for a trip to the Far East, redelivery Taiwan–Japan range. Duration 60–65 days	25%
P3A_03	Delivery Japan–South Korea for a trans-Pacific round voyage, either via Australia or NOPAC, redelivery Japan–South Korea range. Duration35–50 days	25%
P4	Delivery Japan–South Korea for a trip to continental Europe (via US West Coast–British Columbia range), Redelivery Skaw–Gibraltar range. Duration 50–60days	25%

Notes: This table presents the definitions of the Baltic Panamax Index routes as of November 2008.
ECSA stands for East Coast South America; NOPAC stands for North Pacific.
Routes 1A_03, 2A_03, 3A_03 and 4_03 are based on a 'Baltic Panamax' vessel of the following specifications: 74,000 mt dwt vessel, not over seven years of age with a cargo-carrying capacity of 89,000 cbm grain. Maximum LOA 225 m and maximum draft 13.95 m; the vessel is capable of about 14 knots on 32 mt/day fuel oil when laden and 28 mt/day fuel oil when in ballast, with no diesel consumption while at sea.
Source: Baltic Exchange as cited in Alizadeh *et al*, (2009 p. 110).

An index is intended to closely track and replicate the actual movement observed in the physical market. In order to do so the index is composed of individual routes, cargo types, cargo size, voyage charter/time charter etc which are weighed appropriately in order to result in the overall index acting as a representative indication of the associated market. For example, as shown in the table for BPI definition, the index aims to track the movement of the physical spot markets for Panamax sized vessels (74,000 dwt). It uses four voyage routes and weighs them equally. The composition of index is changed and updated from time to time in order to produce track the market movement as accurately as possible.

The indexes are published to the market by the Baltic exchange at 1300 hrs London time. The calculation for the actual index is based on careful assessment by the panellist of the information provided by independent international shipbrokers. In reaching the assessment, the panellists take into account all the relevant information appropriately adjusted with the route definitions. The guiding principle for route definitions is the *Manual for Panellists* produced by the Baltic Exchange.

3.5 Basis risk

In an ideal situation, any gains or losses incurred in the physical market must be offset by the losses or gains in the forward market. This in other words would mean that if the underlier changes exactly as the change in the physical markets then the players can plan and achieve perfect stability in cash flows. In order to achieve such a situation, the underlier and the physical markets must be perfectly correlated and such a hedge is called perfect or text-book hedge (Alizadeh *et al*, 2009: p. 17). In case of perfect hedge the hedged portfolio will have no variability in the outcome since the gains and losses are offset between the two markets.

In practice hedging is associated with a certain amount of risk. The underlier is does not move perfectly with the physical markets. As a consequence this can lead to the ineffective cover of the hedger's position. This risk is known as basis risk and is caused due to imperfect correlation between the spot and forward prices. Also this causes the outcome of the hedged portfolio to deviate from the expected outcome.

Since it costs a firm to pursue a hedging portfolio, therefore a firm would pursue hedging only if the gain in expected outcome is greater than the cost of hedging. Thus the firms hold a portfolio consisting of a combination of futures and spot holding. This ratio of the futures and spot holding is known as *hedge ratio* (Alizadeh *et al*, 2009: p. 18) and should ideally be such that it minimises the risk of the hedged position.

3.6 FFA market

The basic principle of FFA market is to bring together two market players with opposite expectations of the future movement of the underlying. Thus a ship-owner or a ship-operator, who expects the future freight rates to fall, would intend to sell an FFA, thereby locking the freight rate level for the future. While on the other hand, a charterer who expects the market to rise, there by leading to higher future freight, would buy these FFA, thus locking the freight rates for her cargo. This activity of buying and selling the FFA in reality is much more complicated and involves other parties, the most prominent being the FFA broker.

The FFA contracts are negotiated and agreed on the routes, date, month, year of settlement, agreed quantity or duration for time charter the contract rate and settlement rate at which difference will be settled (Alizadeh *et al*, 2009: p. 133). A FFA contract follows the *freedom of contract* principal i.e. the parties are allowed to enter into a contract while incorporating terms and conditions suited to their requirement with mutual agreement. In order to facilitate the process of FFA trading the Forward Freight Agreement Brokers Association (FFABA), the group of brokers dealing in FFA trading, have developed a standard contract known as the FFABA contract. Also the second type of contract common in the FFA trading is the International Swaps and Derivatives Association (ISDA®) Master and Schedule contract.

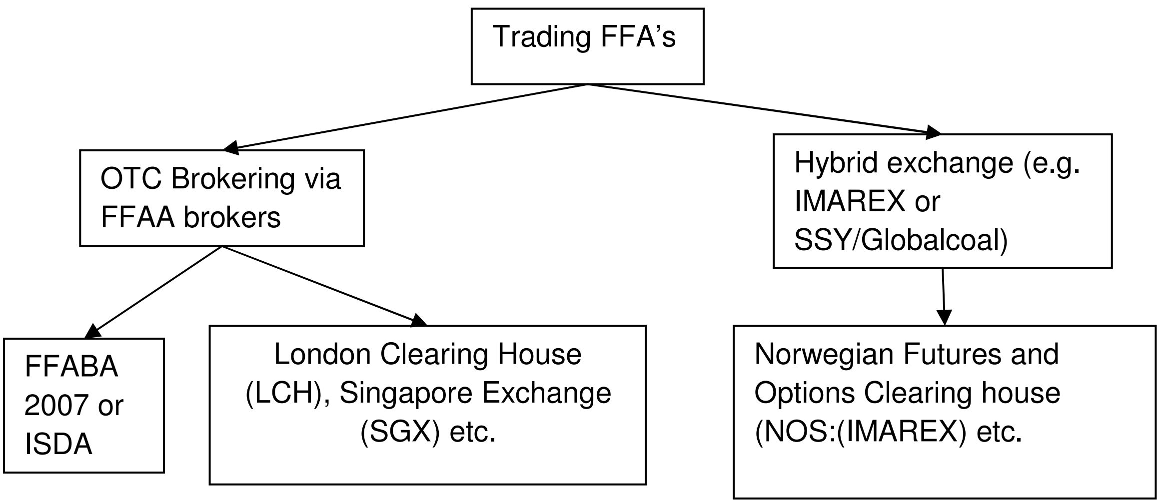


Figure 6 Trading structure of the FFA market

Source: Alizadeh *et al*, (2009 p. 132)

The FFABA contract is a standard contract which contains the main terms of an FFA contract (as detailed in previous paragraph). The first version of this contract was developed in 2000 and was known as the FFABA 2000. This contract lacked the provisions setting forth in the events of default, termination and close-out netting rights (Kennedy *et al*, 2007). Also, once trading started using FFABA 2000, further shortcomings were unveiled. This led to the contract being modified and development of FFABA 2005. Eventually further changes have been incorporated in FFABA 2007 and subsequently FFABA 2009 were introduced.

ISDA is a trade organisation aiming to encourage efficient and prudent development of principal to principal privately negotiated derivative market. The ISDA contract sets forth the legal and commercial relationships between the contractual parties in the Master agreement, while any amendments to the master agreement are set forth in the attached schedule (Kennedy *et al*, 2007). The ISDA contract enjoys an advantage from the legal point of view on the fact that it uses a standard contract form for majority of different derivative traded commodities. The choice of law is defined in the schedule as York law or English law which govern the contract. This reduces the legal risks and uncertainty surrounding the ISDA contract compared to FFABA contract.

The FFA trading pays specific emphasis on maintaining the anonymity and not publicising the identity of its participants unless specifically authorised. Hence currently two major methods for indulging in the FFA market are common: Over the counter (OTC) trading and trading through hybrid exchanges.

For OTC trading the FFA deal is brokered by specialised brokers (refer figure 5). In this system, the participant appoints a broker. The broker understands and analyses the trading requirements of the principal. With these details, the broker searches for a counterparty that is willing to accept the offered terms. The broker in this process matches the 'bid' (the price of highest buyer) and 'offer' (the price of the lowest seller). Thereafter the terms and conditions of the FFA deal are agreed by both the parties. Once this is done, the FFA is finalised and signed. At this point it becomes important to note that since the broker is only an agent for the deal, thus he holds the responsibility of prudent behaviour but is not responsible for the non-performance of the other party. Therefore the parties must ensure caution while choosing their counterparty to minimise the credit risk. These principal to principal deals are known as *FFA swaps*. Alternately the parties can choose to minimise their credit risks by choosing to clear the contract through clearing house.

The hybrid exchanges also are used for FFA trading. In this system, the standardised contracts are traded and cleared through clearing house exchange. A clearing house is a well capitalised financial institution which guarantees the performance of both parties (Alizadeh *et al*, 2009: p. 138). The clearinghouse holds a security deposit from its members, against default, at the time of providing membership. Also, it keeps a regular track of the member's margins, positions and ability to honour their commitments. Hence, the credit risk is minimised when the contracts are cleared through clearing house. Besides this, the liquidity of the contracts traded in the clearing house is greater than FFA swaps. These are known as *FFA futures*. Currently over 95% (Erichsen, 2009) of the overall trade is cleared through organised exchanges.

The contracts are cleared on the last trading day of the month. The settlement price is calculated on the basis of the terms and conditions agreed in the contract. For standardised cleared contracts the settlement price for voyage charter is calculated as the average over the last seven days period and in case of time charter FFA contracts, the price is calculated as the average of the last month prices.

3.7 FFA case study

In this section, the use of FFA as a hedging tool would be established using a case study. The perspective taken in the following case is from a ship-owners side, though a similar outlook can be expressed from a cargo-owners perspective too. Also for simplicity, factors such as freight broker's commission etc have been neglected.

It is currently 10 September 2010 and Mr. George, the owner of cape 150,000 dwt cape size vessel, earns US$ 20/mt of cargo carried. Mr. George, though currently satisfied with the improving dry bulk market, is extremely worried about the possibility of further slowing down of the world economy due to possible discontinuation of the stimulus packages by the governments. Hence, considering the situation he expects the freight market in January 2011 to fall to below the current prices. Thus in order to protect himself from this possible loss of earnings due to fall in the freight rates, Mr. George decides to use FFA. He gets in touch with his FFA broker and expresses interest in sale of 130,000 mt of cargo for route C4 (150,000 mt of coal, Richards Bay to Rotterdam) at US$18.5/mt. The broker searches for a counter party, which turns out to be a coal importing company in Rotterdam expecting a rise in coal demand in Europe. The counter party is unwilling to agree on the rate of US$18.5/mt but requests for a rate of US$17.5/mt.

Mr. George cautious of the offer of US$17.5/mt creates a pay-off chart for a rate of US$18/mt (figure 7). He observes that in case he is able to lock in the FFA rate of US$18/mt, the he would lose US$130,000 in the FFA market in case the FFA market rises to US$19/mt, while on the other hand he would gain US$195,000 in the FFA market if the FFA rates dip to USD16.5/mt. Therefore, after assessing his pay-offs in different scenarios, Mr. George is willing to agree for a deal at US$18/mt.

The two parties agree after negotiations finally agree to a price of US$18/mt with the settlement on route C4 and settlement period as average of last 7 days of January 2011. The contract is signed and Mr. George takes the short (seller) position and Coal Company takes long (buyer) position.

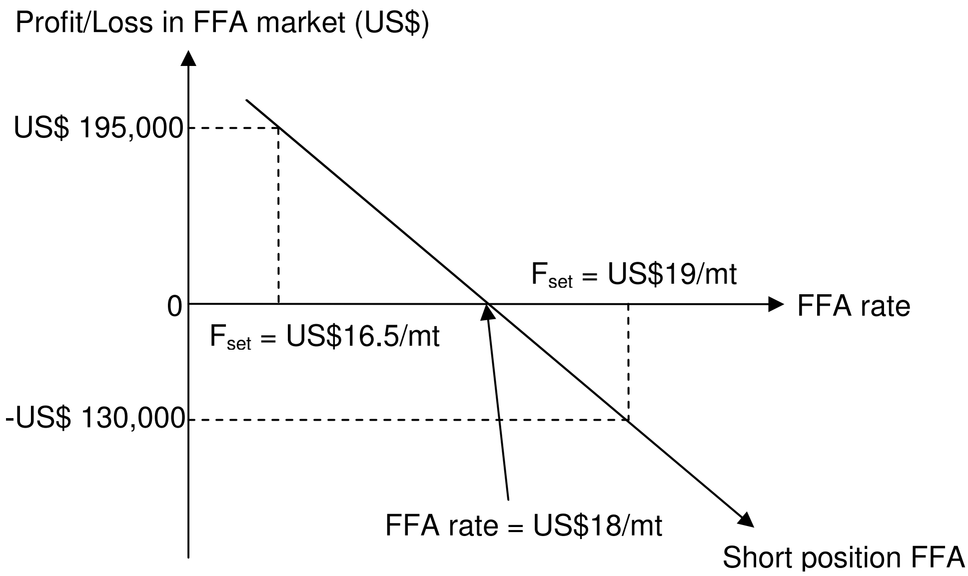


Figure 7 Payoff from short position: Route C4 for 130,000 Tons cargo

Source: Adapted from Alizadeh *et al*, (2009, p. 150)

In January 2011, Mr. George's fears come true and the freight rate for the physical market falls to US$ 16/mt. On calculation of the settlement price for agreed route, the price is found to be US$ 16.5/mt. Thus in this case the Coal Company pays Mr. George an amount of 130,000*(18.5-16.5)= US$ 260,000. This profit from the FFA would help Mr. George offset the losses incurred due to fall in freight rates in physical market. It may seem that the Coal Company made a loss of US$260,000 in the FFA market, but on looking at the bigger picture, it has benefitted from the lower freight rates in the physical market and it can be argued that overall, the Coal Company has gained compared to its expectations of US$18.5/mt of coal.

At this stage, it may be argued that Mr. George would still make a loss of 130,000*(16.5-16)= US$65,000 due to the difference between the actual charter price and the index price. This difference refers to the hedging efficiency of the FFA market. If Mr. George could better design his hedging strategy such that the underlying index could accurately follow the actual physical market, then he would have been able to lock in the freight rate of US$ 18.5 and the FFA and the spot markets would have offset any differences.

3.8 Link between the FFA and spot markets

As observed for the preceding example, the FFA markets are linked to the spot markets only through information. This leads to the peculiarities faced by the two shipping markets which can be attributed to the absence of cost of carry arbitrage link between the two. Firstly it makes it difficult to identify risk-less arbitrage and thus making it difficult to understand market efficiency (Kavussanos *et al*, 2004*a*: p. 242). Secondly, the link between the markets is defined by the expectations and availability of information with the market players. Thus the direction of movement of the markets is strongly dependent upon the outlook of the players as well as how well informed they are. From a research point of view, even though it is assumed that the behaviour of market players is rational and they are completely aware of all information but might not be the case in reality.

The relationship between the paper and the spot markets can range between extremes of perfect correlation to no relation at all. Between the two ends lie the phenomenon of lead-lag relationship, volatility spill over, price discovery and most importantly informational link through the market information as well as the underlying index (e.g. underlying BDI captures the overall dynamics of the spot market of dry bulk shipping market).

Chapter 4 Literature review

4.1 Introduction

This chapter aims to overview the current studies undertaken in the field of FFA markets for dry bulk. It is observed that even with almost two decades of existence, the research done over FFA still remains quiet limited. This can be attributed to the fact that FFA's are principle to principle contracts designed to suit the requirements of the parties hence characterised by high levels of confidentiality. This means a lack of availability of reliable data to be used as a basis of research (Kavussanos *et al*, 2004*b*: p. 274).

This chapter attempts to answer the following questions:

- What study has already been conducted in the field of FFA pricing relation to spot pricing?
- What are the results and conclusions achieved in these studies?
- Link between the existing literature as well as identify any potential gaps

Overall literature can be divided into three broad categories viz. the FFA market, the spot market and relationship between the two markets. In the header for FFA market, the topics covered include the fundamentals of the FFA market, details of underlying, modelling of the underlying and the FFA market dynamics, efficiency of the FFA market and current penetration and utilisation of the FFA contracts. For the spot market though large number of studies are available, but for the objective of this thesis studies only relating to the fundamentals of spot market and modelling of spot market are selected. The third and the majority of the literature in this section focuses on the relation between the spot and FFA markets. This includes papers studying the relationship between the FFA and spot markets, price discovery function of FFA markets, causality relationship, etc.

4.2 Literature Review

The research question of the thesis is to further the understanding of the short term effects of the FFA market on the spot market. This includes understanding the cause of the link between the two markets as well as looking at the possibility of this ability to influence the markets by parties such as the government and speculators. The methodology used to find answers to these questions is based on extensive literature review, analysing them and drawing logical conclusions. Since the literature on the subject of FFA currently remains quite limited hence the literature reviewed consists of the existing research in the field of FFA trading as well as literature from cross-section of the industry and other relevant research papers.

Although the BIFFEX contract was stopped in April 2002, it provides a good starting point for understanding the dynamics of the FFA market. Denning *et al*, (1994) investigates the stochastic nature of BIFFEX prices, volumes and the BFI (Baltic Freight Index). The study is important since the presence of a trend in the futures market could potentially allow traders to exploit markets to gain profits from trading in the futures market. Also it was the starting point for studying the possibility of any patterns observed in shipping markets. It uses the data from 5 May 1985 to 31 December 1989 obtained from the Baltic Exchange for the purpose of the study. The findings suggest that the hypothesis that the price and volume confirm to stochastic process cannot be rejected. It rejects the presence of seasonal pattern in futures contract. Though, they reject the random walk hypothesis for the BFI index. This study is extended to the FFA market by Batchelor *et al*, (2007). Batchelor *et al*, (2007) identifies that the forward rates are helpful in forecasting spot rates. Moreover in order to model the trends, the study concludes that VECM model provides best in sample fit for the futures rate, but are unhelpful in predicting forward rates but Autoregressive Integrated

Moving Average (ARIMA) or Vector Autoregressive (VAR) model are better forecasters. It illustrates the dangers of forecasting in case when the underlying market is evolving and the coefficients and estimates conflict with sensible priors.

The short run relation of the spot and BIFFEX futures market are analysed by Haigh (1998). It uses cointegration followed by Error Correction Model (ECM) to analyse the long-run as well as short-run relationship between spot and futures market. It analyses the relationship between one month BIFFEX contract with the spot rates from the period of July 1988 up to September 1997. Even though the study can be considered outdated, it provides useful inputs for understanding the methods to analyse the short run relationships between the two variables. It concludes that the futures market and the spot market are in long term efficient[2] but experiences short term deviations.

The study of unbiasedness[3] of the BIFFEX contract as a predictor of future spot prices was conducted in Kavussanos *et al*, (1999). Kavussanos *et al*, (1999) used cointegration technique, as developed by Engle *et al*, (1987) and Johansen (1988) (as cited in Kavussanos *et al*, (1999 p. 357)), to test the unbiasedness. This means that, assuming risk neutrality (or no-risk premium) and rationality of expectations to be true, if the future prices, $F_{t;t-n}$ (contract maturity at t and duration n), contain all relevant information to forecast the spot prices for S_t, then $F_{t;t-n}$ should be an unbiased predictor (Kavussanos *et al*, 1999 p. 356). The result indicates that future prices for one and two months before maturity are unbiased forecasts of the realised future spot price where as a bias exists for three month maturity period. This study is furthered by Haigh (2000) who also performed similar test as Kavussanos *et al*, (1999) for unbiasedness of BIFFEX futures for predicting future spot market rates using co-integration technique. The results obtained claim one, two and three (quarterly) month contracts to be unbiased predictors of future spot rates. This is unlike Kavussanos *et al*, (1999) prediction which claims the three month prediction to be biased. The difference between the two results can be owed to the smaller sample size of the data used by Haigh (2000).

The unbiasedness for FFA market is covered by Kavussanos *et al*, (2004*c*). It studies the unbiasedness of using FFA's as predictors for spot rate for various shipping routes and three different time periods i.e. one, two and three months maturity. It uses vector error correction model (VECM) Johansen (1988) as cited in Kavussanos *et al*, (2004*c* p. 244)) in cointegration framework. The finding concludes that the FFA's are not unequivocally unbiased but are dependent upon the route as well as the time period for which the FFA is used as a basis of prediction. Their forecasting accuracy decreases with an increase in maturity period. For one and two month, FFA was concluded to be an unbiased estimator for spot rates while for three months it was found to be biased on Atlantic routes and unbiased on Pacific routes. In extension to Kavussanos *et al*, (2004*c*), further study has been carried out by Groder (2010*b*). The study analyses the period from 2005-2010. This is particularly important due to the fact that the FFA trading in this period has increased substantially (as compared to the 1990's) and hence the market is much more liquid. This increased liquidity allows players to enter as well as exit easily there by reducing the barriers to entry and exit and facilitating presence of many market players. The study uses VECM and cointegration technique for developing the model. The results of Groder (2010*b*) find that for the four analysed routes (Route P1A, P2A, P3A and P4A of Baltic Panamax Index), the one, two and three month FFA prices are unbiased predictors of the future realised spot rates. Also it observes that there is no systematic risk premium[4] in the investigated FFA routes and agents have rational expectations i.e. they do not make systematic errors in their forecast.

[2] No arbitrage
[3] In light of the given information, the estimator predicts the future value dependent variable
[4] Refer section 2.3

Hence Groder (2010*b*) does not reject the hypothesis of efficient FFA market for the investigated routes.

Kavussanos *et al*, (2004*b*) investigates the effect of the introduction of FFA trading on the spot market volatility on four Panamax routes: 1, 1A, 2 and 2A. It studies the link between volatility and information and of possible asymmetric effects on conditional volatilities using a GJR-GARCH (Generalized Autoregressive Conditional Heteroskedasticity) Glosten *et al*, (1993) (as cited in Kavussanos *et al*, (2004*b*)) model. The study of asymmetric effects is done to understand the response of the market to availability of new information depending on the positive or negative shocks generated by this information. The study concludes that the FFA trading has had a stabilising impact on spot market for all investigated route and has not had any detrimental effects on the trading in spot market. Also it finds that there is an improvement in the way information is transmitted into spot market after the introduction of FFA. This improved transmission in information is observed by a decrease in the results of unconditional volatility estimates in routes 1,1A and 2A. For route 2, the unconditional volatility has increased which does not point to the stabilising effect.

The first study to analyse the effect of FFA trading on spot market, and vice versa, is Kavussanos *et al*, (2004*a*). It contributes to the literature of inter-temporal spot and forward prices for non-storable commodity[5]. This paper concentrates on the most liquid and widely traded amongst the FFA's, Panamax routes. It considers Panamax voyage routes 1 and 2 and time charter routes 1A and 2A for the purpose of analysis. The data used is the FFA prices and daily spot prices for period 16 January 1997 to 31 July 2000 for Panamax Atlantic routes 1 and 1A while for Panamax Pacific routes, 2 and 2A, it uses the period 16 January 1997 to 30 April 2001. The results conclude that the FFA prices seem to play the leading role in incorporating new information. This is in agreement with studies carried out in other sectors. To cite some of such studies, Chan (1992) studies the lead-lag relationship [6]between the Major Market cash index and return of Major Market Index futures for S&P 500 futures, and concludes that future source is the main source of market information. Similarly, Floros *et al*, (2007) studies the lead-lag relationship between the spot and futures market in Greece and observe that the futures market plays an important role in price discovery and hence acts as a useful source of information for stock prices. The later study for this topic is performed by Groder (2010*a*). It investigates the issue of "forecasting shipping rates" using FFA prices. Groder (2010*a*) uses routes P2A and P3A from January 2005 up to January 2009 as the underlying data for study. As per his findings, the VECM outperforms RW (Random Walk), ARIMA (Autoregressive Integrated Moving Average Model) and VAR (Vector Autoregression Model) as a source of best model for forecasting forward or spot prices. It finds that in a period of high volatility the spot rates lead the forward rates and in case of low volatility the forward rates lead the spot rate. It also comments, contrary to the findings of (Kavussanos, *et al*, 2004*c*), that even though a bi-directional relation exists between the spot and the forward market, the influence from the spot market is stronger.

Prokopczuk (2010) empirically aims to study the pricing and hedging of dry bulk freight futures contract traded on the International Maritime Exchange (IMAREX) and covering single route and identify the best fitting for pricing as well as hedging effectiveness. It considers four routes, namely, capsize voyage charter C4 (Richards bay to Rotterdam), C7 (Bolivar to Rotterdam) and panamax time charter routes P2A (Gibralter to Far East) and P3A (Pacific round) for the purpose of study. The data considered is for the period of 2005 to 2009. It considers four different models: Black (1976), Schwartz (1997), Schwartz *et al*, (2000) and Korn (2005) (as cited in Prokopczuk (2010)). For investigation the spot prices for Black (1976) and Schwartz (1997) are considered as a function of single stochastic factor, while for Schwartz *et al*, (2000) and Korn (2005) are considered a function of two stochastic

[5] Refer section 3.2
[6] Refer section 5.3

factors, one to capture short term deviations and other to capture long term variations. The empirical results conclude that the two-factor models are more effective for pricing and hedging performance and Schwartz *et al*, (2000) was recommended against the Korn (2005) model.

Kavussanos *et al*, (2003) studies the price discovery function of the futures market. It concludes that the information from the futures market can be used to generate more accurate forecasts for the spot market but not the other way. This reflects that causality from futures to spot runs stronger than the other way and that most of the variability in the futures returns is attributed to pure innovations which cannot be predicted[7] (Kavussanos *et al*, 2003 p. 225). Besides this, it also concludes that the futures prices tend to discover new information more quickly than the spot markets.

Kavussanos *et al*, (2010) looks at improving the understanding the shipping freight FFA's by testing the effect of commodity futures linkages with the FFA. It studies the Panamax time charter (PTC) routes, P1a_03, P2A_03, P3A_03 and P4A_03 on the shipping FFA side and on the commodity front it considers the major commodities which are carried by Panamax vessels i.e. wheat, corn, soya beans and API 14 coal futures and all these put together constitute a synthetic basket which is an equally weighted basket of the four commodities. The analysis is carried out using the pairs of PTC-synthetic basket, PTC-corn futures, PTC-wheat futures and PTC-Soya beans futures. The statistical tests used in the study include cointegration and VAR. The results conclude that grain (corn, wheat and soya beans) seem to be important commodity markets to monitor the FFA market dynamics. Also, construction of such synthetic baskets can be useful for improving the prediction of FFA markets.

Dinwoodie *et al*, (2003) aims to understand the current use of FFA's in the tanker market. It uses a qualitative approach to gather data through extensive questionnaire, interviews and exploratory communication with ship-owners, ship-brokers and charterers. The study looks at the general attitude of market players towards risk and FFA. It also tries to understand the knowledge and outlook of the players on the working of paper trade. It concludes that even though FFA was viewed as an important phenomenon, but some respondents were unaware of the function and many respondents had not used them. The reason for lack of use of tanker FFA was found primarily as the lack of liquidity. Besides this the other factors include basic risk, possibility of default risk since the clearing house does not guarantee performances of FFA and credit risk.

The review of literature brings out certain areas which would require potential further research:

- Potential effects of clearing of FFA contracts by clearing house on the overall FFA volumes and volatility of FFA contracts.
- Study for trends and specific patterns in the FFA markets.
- Study of FFA prices using the lagged forward, spot as well as commodity prices.
- Short run effects FFA trading on volatility of the spot markets and vice versa.

[7] It is observed that conditioning futures to lagged spot prices does not improve the forecasting accuracy of futures prices. Also the VECM explained only 2.9% of the variability in futures return thus suggesting that variability in futures returns represent pure innovations which cannot be predicted (Kavussano *et al*, 2003 p. 225)

Chapter 5 Short term effect of FFA trading on Spot market

5.1 Introduction

The objective of this chapter is to analyse the short run effect of FFA market on spot market. In order to do so it studies three characteristics: cointegration, causality and prediction efficiency. The following section provides the details of the mathematical models and the studies.

5.2 Relationship between FFA and Spot rates

In order to verify the existence of long run relationship between the FFA and spot prices a test for cointegration is the performed in all studies. Cointegration exists between two or more time varying series if it yields a common stochastic drift between the series which individually follow a higher order of integration[8]. This relies on the basic relationship that if the variables are correlated then the relationship between them should ensure that the series do not drift apart from each other (Groder, 2010*b*).

Two main tests are discussed in the literature to test for co-integration: The Engle Granger two-step method (Engle *et al*, 1987) and the Johansen procedure (Johansen, 1988) method. As per Engle *et al*, (1987) (as cited in Groder (2010*b*)) two non-stationary variable are co-integrated if the variables are integrated in the same order and if there exists a linear combination of two variables that is *I*(0)[9]. The Johansen (1988) approach on the other hand uses the rank of coefficient matrix (Π)[10] to comment on the co-integration. The latter approach is considered a better approach since it can be used to study cointegration between non-stationary processes with different order of integration.

The test for cointegration uses a restricted VAR (Vector Auto Regression) model known as VECM (Vector Error Correction Model). VECM uses an error correction term included in VAR to test for cointegration. Thus in order to estimate cointegration, the following model is estimated (Johansen, 1988):

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \sim dist(0, H_t) \ldots (5.1)$$

Where

Δ= First difference operator indicating the change in the variable from previous period
X_t= px1 vector. In case of spot and FFA study, 2x1 vector $(F_{t,t-k}, S_t)$ of log spot and log FFA
μ= px1 vector, Intercept term
H_t= pxp time varying variance/covariance vector

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[8] Order of integration defines the number of differences required to achieve a stationary series.
A stationary process is a random process where joint probability distribution function does not vary with time (Haag, 2005). For first order stationary function with probability density function f_x and for all time shift k:

$$f_x(x_{t1}) = f_x(x_{t1+K})$$

where probability density function $f_x(x)dx = \Pr(x < X \leq x + dx)$
For second order stationary function, with probability density function f_x, values of x_{t1} and x_{t2} and for all time shift k:

$$f_x(x_{t1}, x_{t2}) = f_x(x_{t1+K}, x_{t2+k})$$

[9] *I*(0) refers to order of integration *I*. It means no differences required to achieve a stationary process i.e. the process in its current form is stationary.
[10] Please refer VECM in annex *statistical tools*

Γ_i= ($A_1 + A_2 ... + A_i - I$); Gives information about short run adjustments
I= Identity matrix
Π= A pxp coefficient matrix, ($A_1 + A_2 ... + A_k - I$) and $\alpha\beta' = \Pi$
K= Number of lags
ε_t= Stationary 2x1 vector residual
P= Number of variables (2 in this case)
ΠX_{t-k} : Error correction term

This cointegration framework has been used by different authors for varying time periods, for different routes using data from different maturity periods. From a review of the co-integration tests from all the literature we observed that the test has only been conducted for Panamax FFA's. This can be attributed to the fact that the Panamax route constitutes almost 50% of the total volumes of FFA market and thus is the most liquid of all the FFA's traded. The study by Kavussanos *et al*, (2004*a*) use the daily spot and FFA prices in Panamax Atlantic routes 1 and 1A from period from 16 January 1997 to 31 July 2000 and in Panamax Pacific routes 2 and 2A from 16 January 1997 to 30 April 2001. The results for λ_{trace} and λ_{Max} [11] finds statistically significant results (at 95% confidence level) for accepting the rank coefficient matrix (Π)[12] equal to 1 and thus support the hypothesis of cointegration in all four examined routes.

Similar test conducted by Groder (2010*b*), who uses the Johansen (1988) approach for testing cointegration for routes P2A (Basis delivery Skaw-Gibraltar range, for a trip to the Far East Redelivery Taiwan-Japan range, duration 60-65 days), P3A (Transpacific round of 35/50 days either via Australia or Pacific (but not including short rounds such as Vostochny (Russia/Japan), delivery and redelivery Japan/South Korea range) and 4TC (Delivery Japan / South Korea range for a trip via US West Coast - British Columbia range, redelivery Skaw Gibraltar range, duration 50/60 days) for period from January 2005 to March 2010 analyses the data for each route of FFA contract. Groder (2010*b*) approach is unlike Kavussanos *et al*, (2004*a*), which creates a "perpetual" FFA contract by weighing the near and distant contracts basis their days from maturity, analyses the FFA for different time maturity periods, one, two and three month maturity periods. The test results in this study also reveal statistically significant results leading to accepting the hypothesis of long run relationship between spot and FFA rates.

Another study addressing the issue of cointegration is Batchelor *et al*, (2007). The study is carried out for Panamax Atlantic routes 1, 1A from 16 January 1997 to 31 July 2000 and for Panamax Pacific route, 2 and 2A for a period of 16 January 1997 to 30 April 2001. The contracts are converted into "perpetual" 22 day FFA contracts as done in Kavussanos *et al*, (2004*a*). It also uses Johansen (1988) approach for testing cointegration. The results also conclude that cointegration exists in all investigated routes.

Groder (2010*a*) also performs an analysis to study cointegration with data for spot and FFA prices for route P2A and P3A for a period of January 2005 to January 2009. Using Johansen (1988) test, it establishes that the spot and the forward rates are cointegrated.

Even with most of the studies accepting long run cointegration between FFA and spot rates, the results for Kavussanos *et al*, (2004*c*) are not in complete agreement with these results. As per Kavussanos *et al*, (2004*c*), the study carried out for routes 1, 1A, 2 and 2A for one, two and three months maturity period, the results do not provide sufficient statistical evidence for concluding cointegration for routes 1 and 1A in three months-maturity.

[11] Please refer VECM in annex *statistical tools*
[12] Please refer VECM in annex *statistical tools*

Thus we observe that the studies agree on the presence of cointegration for one and two month periods on the investigated routes, but there are results against cointegration for three months maturity. Thus it may lead to considering the possibility that for increased maturity period the FFA markets do not link well with the spot markets.

5.3 Causality between FFA and Spot markets

Causality between two variables refers to the fact that one variable *causes* the other. This is an extension to the cointegration results for the fact that for long run cointegration to exist a causality relationship in at least one direction needs to be present (Granger, 1988). Thus causality is unlike correlation which indicates a relation between two variables. It is an important factor to understand answer the research question for the reason that even though cointegration is concerned with long term relationship but causality in mean is concerned with short term (Granger, 1988).

Causality provides useful insights for understanding the lead-lag relationship between the two variables. Though, in case of contemporaneous movement, one variable does not provide information for the movement of the other variable.

Study of causality is based on the model proposed by Granger (1988). As per this, for cointegrated *I*(1), x_t and y_t will be generated by an 'error correction' model taking the form:

$$\Delta x_t = \gamma_1 z_{t-1} + Lagged\Delta x_t, \Delta y_t + \varepsilon_{1t} \ldots (5.2)$$

$$\Delta y_t = \gamma_2 z_{t-1} + Lagged\Delta x_t, \Delta y_t + \varepsilon_{2t} \ldots (5.3)$$

$\gamma_1, \gamma_2 \neq 0$
$\varepsilon_{1t}, \varepsilon_{2t} \sim iid(0, H_t)$ are finite-order moving averages

This model has been applied to the FFA and spot market study by Kavussanos *et al*, (2004*c*) Groder (2010*a*) and Groder (2010*b*) etc. (also refer to equation 5.1).

$$\Delta S_t = \sum_{i=1}^{k-1} a_{S,i} \Delta S_{t-i} + \sum_{i=1}^{k-1} b_{S,i} \Delta F_{t-i} + a_S\, z_{t-1} + \varepsilon_{S,t} \ldots (5.4)$$

$$\Delta F_t = \sum_{i=1}^{k-1} a_{F,i} \Delta S_{t-i} + \sum_{i=1}^{k-1} b_{F,i} \Delta F_{t-i} + a_F\, z_{t-1} + \varepsilon_{S,t} \ldots (5.5)$$

Where:
$a_{S,i}$, $b_{S,i}$, $a_{F,i}$ and $b_{F,i}$ are short run coefficients
z_{t-1} is the error correction term (ECT) = $(S_{t-1} - \beta_2 F_{t-1} - \beta_1)$

For unidirectional causality to exist from FFA to spot, either of the two conditions must be satisfied: (i) at least some coefficients (i=1,2,..k) of $b_{S,i}$ must be non-zero and/or (ii) error correction coefficient, a_F, in equation 5.4 is significant at conventional levels. Similarly, for spot to FFA causality (i) some terms for $b_{F,i}$ for i=1,2,...k must be non zero and/or (ii) coefficient of error correction term, a_F must be significant at conventional levels. This can be explained in a simple manner by considering the fact that coefficient for ΔF_{t-i} being non-zero (in equation 5.4) implies that the previous FFA rates contribute play a role in the spot rate estimation. Similarly, since z_{t-1} is a linear combination of ΔS_{t-1} and ΔF_{t-1} hencea_S being non-zero also indicates an effect of FFA prices on spot prices. In case if all these mentioned coefficients were zero then FFA rates would not be useful for predicting the spot rates. Thus a case of non-zero coefficient would mean FFA rates *cause* the spot rates and hence hold a causality relationship from FFA to spot. Similarly spot to FFA causality relationship can be explained. These hypotheses are tested using Wald coefficient test [13](Groder, 2010*b*).

The investigation of causality relationship for FFA and spot markets has been carried out in four studies: Kavussanos *et al*, (2004*c*), Batchelor *et al*, (2007), Groder (2010*a*) and Groder (2010*b*). The results of Kavussanos *et al*, (2004*c*) find the coefficients of error correction term (ECT) a_S and a_F are statistically significant. Since a_S and a_F coefficients are indicators of adjustment in the long run hence they are useful to comment on how will the two markets respond to changes. They suggest which of the two (FFA or spot) will move to correct variation from long term equilibrium (i.e. Spot rate – Forward rate = 0). The results indicate that both spot as well as FFA market respond to correct a shock and reach long run equilibrium and a two-way feedback causality relationship exists. In the study a_S is found to be negative while a_F is found to be positive. Thus it concludes that in response to a shock, FFA prices increase in the next period, while spot prices decrease.

The estimation of lagged own return $a_{S,i}$ $a_{F,i}$ and lagged cross-market returns $b_{S,i}$ $b_{F,i}$ (Kavussanos *et al*, 2004*c*) indicate a bidirectional causality relationship and that both markets, the spot and the FFA, serve as an important point for information assimilation. On observing the magnitude of the coefficients it is observed that coefficients of spot lags in FFA equation are much greater in magnitude than coefficients of FFA lags on spot equation. Thus Kavussanos, *et al*, (2004*c*) suggests that FFA markets seem to play a leading role in assimilation of new information.

On the other hand, study by Groder (2010*b*) finds coefficient for ECT for spot rate equation, a_S not statistically significant while for forward rate equation, a_F as highly significant and positive. Thus Groder (2010*b*) suggests that only forward contracts correct the deviations from long run equilibrium while the spot prices do not react to shocks and deviations from the long run equilibrium. It also suggests that forward market respond quicker to new information and in case of “forecast error” they correct themselves.

Testing the short-run-causality, using Granger (1988) test, Groder (2010*b*) concludes that for one month expiry (current month) only for route P2A forward rate show a causality relation for spot rates. For other routes, no one-directional causation relationship could be established, but a stronger effect of spot rate causality to forward rates. For one month (two months to maturity) and two month (three months to maturity) contracts, causality was established from the spot to forward markets.

Batchelor *et al*, (2007) tests for “Granger Causality” using Granger (1988) approach. The results suggest a two way causality for single lag. For longer lags, the results suggest a causality from FFA to the spot market thus suggesting that FFA leads the spot markets.

Test for ECT coefficients in Batchelor *et al*, (2007) concludes different results for the four routes. It finds that for route 1, forward rates adjust to correct disequilibrium. While for route 2 only spot rates move to correct the equilibrium. In case of 1A and 2A, both spot and forward rates move to correct the equilibrium. The magnitude of forward rate coefficient in route 1, 1A and 2A is observed to be much greater than the coefficient for spot rate. Thus in three out of four routes it is found that FFA rates move to adjust to equilibrium.

The study conducted by Groder (2010*a*) provides the most striking results. The study divides the total data set into three segments (a) January 2005 to January 2006, (b) June 2008 to January 2009 and (c) January 2005 to January 2009. This is done in order to understand the specific causality relationship for periods of high volatility (as in a), periods of low volatility (as in b marking start of financial crisis) and an overall effect.

[13] Wald test is used to test the true value of the parameter based on sample estimates when the relationship between data has to be expressed as statistical model with parameters using the sample

It is observed in the study that in case (a) it is seen that the adjustment coefficients for ECT for spot rates is highly significant and positive, while for FFA is insignificant. Thus during this period spot rates adjust in order to reach the long term equilibrium while the FFA rates do not vary much. In case of (b) for the coefficients for ECT it is observed that the coefficient for FFA rose steadily suggesting that the freight rates adjust to changes in spot rates. For case (c) also it is observed that the forward rate coefficient is greater in magnitude thus indicating that the forward rates adjust to the spot rates.

From the above observations it was concluded by Groder (2010*a*) that in case (a) where volatility is high, forward rates lead spot rates. In case (b) where volatility is lower, spot rates lead FFA rates. The Granger test points towards bidirectional causal relationship between spot and FFA markets. In the long run, i.e. case (c), it is found that the spot prices define the long run equilibrium and lead the FFA rates.

To summarise the results of the studies, they point to the fact that a two way causality relationship does exists between spot and FFA markets for causality for one month expiry contracts. Even though the effect of FFA on spot markets cannot be conclusively commented upon by analysing the literature but the effect of spot market as a causality factor for FFA market is accepted by the studies. For increased period to maturity, two and three month expiry, causality is found to run strongly from spot to FFA markets. This leads to the conclusion that the FFA markets, more importantly, act as an important source for assimilation of new information and respond better to availability of new information in spot markets.

The cause for improved transmission of information can be found in reduced market friction. Kavussanos *et al*, (2004*a*) identifies the reasons for this as: lower transaction costs, trading possibility for multiple routes and time horizons and flexibility to investors.

Lower transaction costs involved in the FFA trading, due to the cashless nature, helps towards better adaption of paper market to information. This would mean that a ship-owner or a ship-operator trading in FFA does not physically have to undertake the actual associated costs of activities such as hiring a vessel or ensuring it being present at the required location at given time. Similarly, from a cargo owner’s point of view too, this provides flexibility for similar reasons of not having a requirement of physical movement or handling of cargo but only paper trading.

This ease of lower transaction cost paves way for the second factor i.e. trading possibility for multiple routes and time horizons. The FFA transaction can be included immediately unlike the long period involved to undertake the physical activity. Also the possibility to trade on multiple routes with an objective of risk hedging (or profit making) without physical constraints gives a greater incentive to react to information.

Thirdly, flexibility to investors reflects on the fact that the cost of hiring the complete ship could be detrimental from the perspective of a market player thus preventing her to shift position in response to slight changes in information availability. The FFA trading allows the participants without undertaking huge capital investments to react to new informatin. Also market players can shift between long and short position by easily by changing trading positions in FFA trading without worrying about huge transaction costs and expenses. This leads to market participants reacting to new information quickly and thus facilitating information assimilation.

5.4 Forecasting performance of FFA’s for predicting spot prices

The forecasting performance of FFA as an instrument to predict spot prices has been undertaken in only one study by Groder (2010*a*). The study compares the forecasting performance of the realised spot prices using past spot and FFA prices within a framework of four models: Random walk, ARIMA model, VAR model and VECM. The supporting study Batchelor *et al*, (2007) which compares the ability of different models to predict the forward and spot prices forms an important basis for understanding Groder (2010*a*).

Batchelor *et al*, (2007) compares the forecasting ability of ARIMA, VAR, VECM and S-VECM models for predicting the FFA and spot rates. These are compared to results of RW (Random walk) as a reference.

The ARIMA(p,1,q) model for spot and forward rates predicts the future value, N days ahead, for first variable using auto regression of the previous lagged values of the variable and the moving average of the white noise error terms. The model as specified in Batchelor *et al*, (2007) is as follows:

$$\Delta S_t = \alpha_{10} + \sum_{i-1}^{p} \alpha_{1i} \Delta S_{t-i} + \sum_{j-1}^{q} \beta_{1i} \varepsilon_{1t-j} + \varepsilon_{1t} \quad , \varepsilon_{1t} \sim iid(0, \sigma) \ldots (5.6)$$

$$\Delta F_t = \alpha_{20} + \sum_{i=1}^{p} \alpha_{2i} \Delta F_{t-i} + \sum_{j=1}^{q} \beta_{2i} \varepsilon_{2t-j} + \varepsilon_{2t} \quad , \varepsilon_{2t} \sim iid(0, \sigma) \ldots (5.7)$$

ΔS_t : Change in log future spot prices
ΔF_t : Change in log future FFA prices
ε_{1t} : Random error term

The corresponding VAR(p) model incorporates the lagged values for the second variable. This model can be specified as Batchelor *et al*, (2007):

$$\Delta S_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i} \Delta S_{t-i} + \sum_{j=1}^{p} \beta_{1i} \Delta F_{t-j} + \varepsilon_{1t} \quad , \varepsilon_{1t} \sim iid(0, \sigma) \ldots (5.8)$$

$$\Delta F_t = \alpha_{20} + \sum_{i=1}^{p} \alpha_{2i} \Delta F_{t-i} + \sum_{j=1}^{p} \beta_{2i} \Delta S_{t-j} + \varepsilon_{2t} \quad , \varepsilon_{2t} \sim iid(0, \sigma) \ldots (5.9)$$

While the third model, VECM, is a restricted VAR (as discussed previously). It incorporates an error correction term Batchelor *et al*, (2007).

$$\Delta S_t = \alpha_{10} + \sum_{i=1}^{p} \alpha_{1i} \Delta S_{t-i} + \sum_{j=1}^{p} \beta_{1i} \Delta F_{t-j} + \gamma_1 (S_{t-1} - \delta_0 - \delta_1 F_{t-1}) + \varepsilon_{1t} \quad , \varepsilon_{1t} \sim iid(0, \sigma) \ldots (5.10)$$

$$\Delta F_t = \alpha_{20} + \sum_{i=1}^{p} \alpha_{2i} \Delta F_{t-i} + \sum_{j=1}^{p} \beta_{2i} \Delta S_{t-j} + \gamma_2 (S_{t-1} - \delta_0 - \delta_1 F_{t-1}) + \varepsilon_{2t} \quad , \varepsilon_{2t} \sim iid(0, \sigma) \ldots (5.11)$$

The last model tested in the study is S-VECM which is a parsimonious and a restricted version of VECM. It uses Seemingly Unrelated Regression Equations (SURE) method instead of Ordinary Least Squares (OLS) method (Batchelor *et al*, 2007).

The forecasting ability of each model is assessed using root mean square error (RMSE) metric. The results indicate that the S-VECM model outperforms all other models in prediction of future spot and FFA rates. In specific context to shorter periods, RMSE of VECM and S-VECM is lower than other models tested. While compared to RW model, all the four models are found to be better predictors. Also it is found that the RMSE from the forward is almost two to three times that of spot thus indicating higher volatility and unpredictability of the FFA rates compared to the spot rates.

These test when performed by Groder (2010*a*) yielding similar results, though in this study, ARIMA forecasting was found to result in worse compared to RW. The forecast accuracy (measured by RMSE again) was found to be best with VECM models, while followed by VAR, RW, ARIMA and finally FFA prices.

The study extends to the forecasting performance of FFA to predict spot prices. This is based on the fact that since FFA's should ideally be equal to the future spot prices, hence the FFA rates in the present period must accuratly predict the future spot rate.

The findings point to the fact that the FFA prices did not predict the spot rate well. On the contrary, RW model provided better estimates and the RMSE for RW was found to be lower than that of FFA RMSE. Thus the study concluded that it doesn't make sense to use FFA's as predictors for future spot prices neither in short or the long (monthly) term horizon.

The two studies are useful in understanding the ability of FFA as a predictor for spot prices. In both studies, it is found that FFA's alone are not useful predictors for estimating future realised spot prices. When used in conjunction with lagged values of spot and FFA rates in VECM and VAR models, the results substantially improved. This can be concluded to indicate to the fact that the FFA's do provide information for future spot rates, but the ability of market players to predict the future spot rates is low (Groder, 2010*a*). Also, between the FFA commencement and maturity period, availability of "unpredictable information" might lead to greater unpredictability.

Chapter 6 Conclusion

6.1 Conclusions

The study of short term effects of FFA market on spot markets has been analysed in three directions: cointegration, causality and prediction ability. Considering the broader outcome, it is generally observed that the spot and the FFA rates are cointegrated in the long run. This leads to the existence of long-run relationship between the two markets and evidence that an equilibrium exists.

The analysis of short term causality relationship though does not provide clear evidence on direction of causality although from the results it can generally be accepted that a bidirectional causality relationship exists between the two markets. The impact of error correction term in most cases suggests that the FFA rates converge towards the spot rates, and not vice versa, in order to achieve long run equilibrium. This leads to an important characteristic of FFA markets that they respond quicker to the availability of new information compared to the physical markets. This has been attributed to three main factors: lower transaction costs, trading possibility for multiple routes and time horizons and flexibility to investors. Another important potential finding, though tested in only one study, points towards the fact that in periods of high volatility spot rates lead the FFA rates while in periods of low volatility, FFA rates lead the spot rates. This could eventually prove a crucial finding for FFA market players in order to correctly assess future movements of FFA or spot markets.

The study of predictability of spot rates by simply using FFA rates for the period is found to lead to extremely poor results. Even though the informational link does exist, this unpredictability has been attributed to two major causes: the expectations of market players for predicting futures does not match with the actual spot rates thus suggesting low ability to predict and/or the inflow of new “unpredictable information” during the period between agreement and the maturity date can lead to higher unpredictability.

Combining these results for the short term effects of FFA trading on spot market, it can be said that even though FFA markets assimilate information better than spot markets, they tend to follow the spot market. Also in case of shocks, the adjustment of the FFA market, in order to achieve the long run equilibrium, is greater than the spot market. Hence evidence suggests a greater impact of spot market on FFA than the other way round. Thus a change in spot market would result in a greater change in FFA market than a similar change in FFA market would effect on spot market. Therefore in the short-run also we observe that the leading function is played by the spot market while the FFA market follows.

6.2 Further research

The thesis uses results and conclusions from literature review which are based on spot and FFA rates for different route in BPI. The primary reason for this is claimed to be lack of sufficient data and low liquidity. Thus the study currently overlooks the FFA and spot market relationship in other segments as well as wet-bulk segment. A potential scope of further study could involve understanding the effects of FFA trading for different indexes. Further it would be important and interesting to perform such a study on effects of FFA trading on spot markets for these sectors. This will help to develop a broader framework for understand the overall impacts of FFA trading.

With the induction and steady growth of FFA trading in the container shipping (Bockmann, 2010), the impact of FFA on spot markets on container shipping can be another important area of study. The container industry, unlike the dry bulk market, is governed by different dynamics with few players controlling a majority of the overall tonnage. Therefore a study aimed at understanding the effects of FFA trading on the container industry will provide an opportunity to examine the dynamics of FFA market in different scenario. This study can be a pioneering breakthrough setting precedence for analysing and understanding the impact of presence of FFA market in the container segment.

Appendix

Statistical tools

Measurement of central location

Mean

	Sample	Population
Mean	$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$	$\mu = \frac{\sum_{i=1}^{N} x_i}{N}$

Where
$\bar{x}, \mu$: Sample mean and population mean respectively
x_i : ith observation of x
n, N : Sample size and population size respectively

Measured characteristic: It is an indicator of the central location point of the data set

Median

It is the central value when all the observation are arranged in order of magnitude, for the given sample or population

Measured characteristic: It is a good measure of central location of skewed data

Mode

It is the observation with the highest frequency for the given sample or population.

Measured characteristic: It is the most commonly observed value (maximum frequency) in the given data

NOTES:

Please refer to coefficient of skewness to identify the nature of tail.

- For a distribution with fat left tail, then

  Mean<Median<Mode

- For a distribution with fat right tail, then

  Mode<Median<Mean

- For symmetric distribution, then

  Mean=Median=Mode

Measurement of dispersion

Variance and Standard deviation

	Sample	Population
Variance	$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$	$\sigma^2 = \frac{\sum_{i=1}^{N}(x_i - \mu)^2}{N}$
Standard Deviation	s	σ

Measured characteristic: Dispersion around the mean. It is the second moment variable around the mean.

For calculating and reporting variance, often percentage change in variable is used instead of the absolute value of the variable. The percentage change for variable can be calculated as the change in value divided by the initial value. Hence

	Periodic	Continuous
Percentage return	$r_t = \frac{P_t - P_{t-1}}{P_{t-1}}$	$r_t = \ln\left(\frac{P_t}{P_{t-1}}\right)$

Coefficient of skewness

	Sample	Population
Coefficient of skewness	$\hat{\alpha}_3 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^3}{(n-1) * s^3}$	$\alpha_3 = \frac{\sum_{i=1}^{N}(x_i - \mu)^3}{N * \sigma^3}$

Measured characteristic: It measures how symmetric the distribution is around the mean. Hence it is an indicator of the shape of the curve. It is the third moment of variable around the mean.

NOTES:

- If $\hat{\alpha}_3 < 0$, then
  The distribution is negatively skewed distribution with left fat tail
- If $\hat{\alpha}_3 = 0$, then
  The distribution is symmetric distribution with left fat tail and right tail equal
- If $\hat{\alpha}_3 > 0$, then
  The distribution is positively skewed distribution with right fat tail

Coefficient of kurtosis

	Sample	Population
Coefficient of kurtosis	$\hat{\alpha}_4 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^4}{(n-1) * s^4}$	$\alpha_4 = \frac{\sum_{i=1}^{N}(x_i - \mu)^4}{N * \sigma^4}$

Measured characteristic: It measures the peakness of the distribution of variables. Hence it is an indicator of how sharp or mound the shape of the curve is. It is the fourth moment of variable around the mean.

NOTES:

The peakness of the observed curve is compared with a normal distribution. A normal curve extensively used in statistics and finance has a peakness of 3. Therefore we can measure and conclude the following

- If $\hat{\alpha}_4 < 3$, then
  Sample distribution is relatively flatter than the normal distribution and is called 'platykurtic'
- If $\hat{\alpha}_4 = 3$, then
  Sample distribution has peakness similar to the normal distribution and is called 'mesokurtic'
- If $\hat{\alpha}_4 > 3$, then
  Sample distribution has relatively greater peakness than the normal distribution and is called 'leptokurtic'

Coefficient of variation

	Sample	Population
Coefficient of variation	$CV = s/\bar{x}$	$CV = \sigma/\mu$

Measured characteristic: Measures the relative spread of data while considering the variance as well as the mean. Higher the coefficient of variance, more dispersed is the data around the mean.

Covariance and correlation

	Sample	Population
Covariance	$s_{x,y} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{n-1}$	$\sigma_{x,y} = \frac{\sum_{i=1}^{N}(x_i - \mu_x)(y_i - \mu_y)}{N}$
Correlation	$\hat{\rho}_{x,y} = \frac{s_{x,y}}{s_x * s_y}$	$\rho_{x,y} = \frac{\sigma_{x,y}}{\sigma_x * \sigma_y}$

Measured characteristic: It is a measure of degree of co-movement of variables x and y

Time varying volatility models

These models are used to capture the volatility of observations which are continuously varying with time. This could be observations such as stock market levels, ship prices, charter rates etc. This requires selecting a suitable time window (number of observations which would be relevant, n) so as to phase out old observations, which have lost significance for the current volatilities but also ensure that the time window is selected to capture the volatility of the market, and move this window to capture the current volatilities of the observed values.

Rolling-window or moving-average variance

This is the simplest model for measuring variance. In this a time window, n (observations), is selected and the variance (σ^2) is calculated. This window is rolled on a set of time varying observation and as a new observation comes in, the oldest observation is dropped out and the new variance is calculated.

$$s^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}$$

Advantages: Simple

Drawback: All observations are weighted equally even though the older observations could hold lesser relevance than the newer ones for current volatilities.

Exponentially weighted average variance (EWAV)

They overcome the shortcoming of rolling-window variance models by weighing the observations by a factor λ. Thus λ is the weighing coefficient such that 0<λ<1. Thus the variance is calculated as

$$\sigma_t^2 \approx (1-\lambda)\sum_{i=1}^{n}\lambda^{i-1}(r_{t-i} - \bar{r})^2$$

or

$$\sigma_t^2 \approx \lambda\sigma_{t-1}^2 + (1-\lambda)r_{t-1}^2$$

The value of λ determines the persistence or memory of the model. A high λ leads to high persistence and vice versa. It has been shown that value of λ between 0.90 and 0.98 are sufficient to capture dynamics of market volatility.

ARCH model

Introduced by Engle (1982), Auto Regressive Conditional Hetroscedasticity (ARCH) is used for modelling variance of time series by conditioning it on the square of lagged disturbances-error terms or shocks in an autoregressive form. In simpler form, it considers the error of current error term to be a function of (often square of) pervious time period error terms.

A dependent variable, r_t, can be defined by explanatory variables, $x_{i,t}$ by using ordinary linear square (OLS), leading to best linear unbiased estimator (BLUE) when the residuals are homoscedastic (have a constant variance). In case the variance varies with time, OLS does not lead to BLUE due to lack of parameter estimates caused by time varying estimates. Thus, as per OLS

$$r_t = \alpha_0 + \alpha_1 x_{1,t} + \ldots + \alpha_P x_{P,t} + \varepsilon_t, \qquad \varepsilon_t \sim IN(0, \sigma_t^2)$$

As per Engle (1982), the variance of dependent variable, which is equal to the error term can be estimated using autoregressive equation

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{m} \beta_i \varepsilon_{t-i}^2$$

β_0 and β_i, i= 1,...,m are parameters of lagged square error terms. In case parameters of lagged square error term are statistically insignificant, then hetroscedasticity (different variances) does not occur. Also basis the number of lagged errors, the model is specified as ARCH (m) model.

GARCH model

This model uses the variance of its own lagged values as well as lagged square error terms.

$$\sigma_t^2 = \beta_0 + \sum_{i=1}^{p} \beta_{1,i} \varepsilon_{t-i}^2 + \sum_{i=1}^{q} \beta_{2,j} \varepsilon_{t-j}^2$$

Basis the number of lagged errors (p) and variance (q) terms, the GARC model is specified as GARCH (p,q). The most common used GARCH model in financial time series is GARCH (1,1).

VECM

Vector Error Correction Model (VECM) is used to test for long run cointegration between variables. Assuming P variables, X_t denotes Px1 vector (matrix) which can be predicted using k previous observation, X_{t-i}, each regressed with coefficient vector A_i, intercept μ and residual error ε_t. This can be represented as VECM (Johansen, 1988)

$$X_t = \sum_{i=1}^{k-1} A_i X_{t-i} + \mu + \varepsilon_t$$

Which is further rearranged into following VECM (Groder, 2010*b*)

$$\Delta X_t = \mu + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \Pi X_{t-k} + \varepsilon_t \sim N(0, \Sigma)$$

Where

Δ= First difference operator indicating the change in the variable from previous period
X_t= px1 vector. In case of spot and FFA study, 2x1 vector ($F_{t,t-k}, S_t$) of log spot and log FFA
μ= px1 vector, Intercept term
Σ= pxp variance/covariance vector
Γ_i= ($A_1 + A_2 ... + A_i - I$); Gives information about short run adjustments
I= Identity matrix
Π= A pxp coefficient matrix, ($A_1 + A_2 ... + A_i - I$) and $\alpha\beta' = \Pi$
K= Number of lags
ε_t= Stationary 2x1 vector residual
P= Number of variables (2 in this case)
ΠX_{t-k} : Error correction term

Notes:

1. Basis the rank (r) of the coefficient matrix (Π) existence of long run cointegrating vector can be commented as follows (for 2 variables in this case, spot and FFA prices)

- r=p=2 : Them S_t and $F_{t,t-k}$ are stationary I(0) i.e. a stochastic process whose joint probability does not change when moved in time
- r=0 : Then there exists no cointegration between the tested variables
- r<p : There exists single cointegration between the variables

In order to test for r, Johansen (1988) suggest that rank of Π will be equal to the number of characteristic roots or eigenvalues (the scalar which only changes magnitude and not the direction) the vector will have. Thus, the number of characteristic roots, for an nxn matrix, will be the values of λ, which would satisfy the value det(Π- λI_n,)=0 where I_n is nxn identity matrix. Johansen (1988), as cited in Kavussanos *et al*, (2004*a*), suggests following two test statistics for testing r:

$$\lambda_{\text{trance}}(\mathrm{r}) = -\mathrm{T}\sum_{\mathrm{i=r+1}}^{\mathrm{n}} \ln\left(1-\hat{\lambda}_{\mathrm{i}}\right)$$

$$\lambda_{\text{Max}}(\mathrm{r}, \mathrm{r}+1) = -\mathrm{T}\sum_{\mathrm{i=r+1}}^{\mathrm{n}} \ln\left(1-\hat{\lambda}_{\mathrm{r+i}}\right)$$

$\hat{\lambda}_{\mathrm{i}}$: Eigenvalues obtained from estimating Π matrix

T : Number of usable observations

λ_{trace} (trace test):

H_0 : Number of cointegrating vectors is at most r

H_1 : Number of cointegrating vectors is greater than r

λ_{Max} (Eigen value test):

H_0 : Number of cointegrating vectors is equal to r

H_1 : Number of cointegrating vectors is equal to r+1

2. $\alpha\beta' = \Pi$

Goodness of fit

Jarque–Bera test

This test is used a goodness of fit used to test for the normality of the given data. It is based on kurtosis and skewness.

$$JB = \left(\frac{n}{6}\right) * \left(S^2 + \left(\frac{1}{4}\right)(K-3)^2\right)$$

Where,

$S = coefficient\ of\ skewness,\ (\hat{\alpha}_3 = \frac{\sum_{i=1}^{n}(x_i-\bar{x})^3}{(n-1)*s^3})$

$$K = Coefficient\ of\ Kurtosis, (\hat{\alpha}_4 = \frac{\sum_{i=1}^{n}(x_i - \bar{x})^4}{(n-1) * s^4})s$$

JB Test: H_0: S=0 and K=3 thus JB=0

Statistic for JB test is an asymptotic chi-squared distribution with two degrees of freedom.

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