11 Freight Derivatives and Risk Management: A Review

Manolis G. Kavussanos and Ilias D. Visvikis

11.1 INTRODUCTION

During the last two decades there has been a significant growth in financial instruments that can be used to address the need of "protection" in the volatile economic environment in which business operate. While financial derivatives products such as futures, forwards, options and swaps, have a long history in the management of risk for various commodities, these instruments have started to be used consistently by the shipping industry only during the last decade.

Shipping markets can be characterized as being capital intensive, cyclical, volatile and seasonal, while shipping companies are exposed to the international business environment. Shipping freight derivatives have the potential to offset (hedge) freight rate risk of the dry-bulk and wet-bulk (tanker) sectors of the shipping industry.[1] The volatility observed in freight rates constitutes a major source of business risk for both the shipowner and the charterer. For the charterer wishing to hire-in vessels for transportation requirements, increasing freight rates leads to higher costs. For the shipowner, lower freight rates involves less income from hiring out the vessels. For a detailed analysis of the business risks prevalent in the shipping industry, and the traditional and derivative strategies that may be used to tackle them see Kavussanos and Visvikis (2006a, 2007).

Freight derivatives can provide real gains for market participants in shipping, as their existence has made risk management cheaper, more flexible and readily available to parties exposed to adverse movements in freight rates. Freight derivatives contracts, compared to time-chartering a vessel (a traditional risk management method), are more effective instruments for managing freight market risks. This is because shipowners retain operational

Contact details: Manolis G. Kavussanos, Ph. D., Professor of Finance, Athens University of Economics and Business, 76 Patission St., 10434, Athens Greece., Email: mkavus@aueb.gr and Ilias D. Visvikis, Ph.D. Assistant Professor of Finance, ALBA Graduate Business School, Athinas Ave. & 2A Areos St., 16671, Vouliagmeni, Athens Greece., Email: ivisviki@alba.edu.gr

[1] In the dry-bulk sector, vessel markets are segmented as follows: Capesize vessels (100 000–180 000 dwt – deadweight) carrying iron ore and coal; Panamax vessels (50 000–79 000 dwt) carrying coal, grain, bauxite; Supramax vessels (52 000 dwt); Hanymax vessels (25 000–49 999 dwt); and Handysize vessels (10 000–24 999 dwt) carrying minor bulks and smaller parcels of major bulks such as grain, coal and bauxite. In the wet-bulk (tanker) sector, vessel markets are segmented as follows: Ultra-Large Crude Carriers (ULCCs, 320 000 + dwt); Very-Large Crude Carriers (VLCCs, 200 000–319 999 dwt); Suezmax vessels (120 000–199 999 dwt); Aframax vessels (75 000–119 999 dwt); Panamax vessels (50 000–74 999 dwt); and Small Product Tankers (Coasters, 10 000–49 999 dwt), all carrying crude oil and oil products.

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control of their vessels and at the same time benefit from favourable spot market conditions. Also, charterers are free from any operational risks which are present in time-charter agreements. Freight derivatives contracts allow entrepreneurs in the sector to get on with the business know best, and yet manage their freight rate risk through this separate "paper" market. Commissions payable to brokers are lower in freight derivatives compared to chartering agreements. The low commission structure and their simple nature imply that it is cheaper and easier to trade in and out of freight derivatives positions prior to the settlement month than trading in and out of physical positions, where the costs are higher. Also, there is no physical delivery involved with freight derivatives. They simply settle in cash upon conclusion of the agreed terms.

Besides the above benefits to principals (shipowners and charterers) freight derivatives are useful to: (i) energy and commodity traders, since they allow them the opportunity to participate in pure trading and/or to hedge their physical shipping exposure; (ii) financial institutions, which participate in this market for proprietary trading and to offer hedging services to their clients; (iii) oil/energy companies/refineries for the opportunity they offer to hedge against the physical shipping freight rate volatility and to create a positive cash-flow management; and (iv) institutional non-shipping investors (such as hedge funds, private individuals, etc.), as they provide the opportunity to invest in a commodity with different cycle patterns compared to other sectors, thus providing the opportunity for arbitrage between sectors and complement/diversify their shipping equities portfolio.

Market participants using the freight derivatives markets come from all sectors of the shipping industry. They include shipowners (20 %), charterers and operators (fleet managers/freight traders, 30 %), trading companies (grain, coal, electricity, oil traders, 40 %), financial houses and banks (10 %). Regional trading during 2006/2007 is estimated to be: 70 % from Europe, 25 % from Asia and approximately 5 % from the US. The value of trading for speculation is more than twice that for hedging, being 70 % and 30 % respectively.

Currently, market participants utilize various derivatives products in order to hedge themselves against the adverse freight rate fluctuations; these products are Over-The-Counter (OTC) and cleared – through a clearing-house – freight forwards, exchange-based cleared freight futures and OTC and cleared freight options. This chapter aims to provide an outline of the characteristics and markets of these products and discuss the empirical work presented in the literature thus far. Section 11.2 discusses forward freight agreements, namely FFAs. Section 11.3 presents the freight futures contracts listed in the specialized maritime products exchange, namely the International Maritime Exchange (IMAREX), and lately at the New York Mercantile Exchange (NYMEX). Section 11.4 discusses the issue of credit risk in FFAs and how the London Clearing House (LCH.Clearnet) and the Singapore Exchange Asia Clear provide solutions to this problem. Freight options are presented in Section 11.5. Section 11.6 outlines the empirical research findings in these markets, while Section 11.7 concludes the chapter.

11.2 FORWARD FREIGHT AGREEMENTS

The first OTC freight derivatives product appeared in 1992 and is called the Forward Freight Agreement (FFA) contract. FFAs are private principal-to-principal Contracts for Difference (CFDs) between a seller and a buyer to settle a freight rate, for a specified quantity of cargo or type of vessel, for usually one, or a combination of the major trade routes of the dry-bulk or tanker sectors of the shipping industry. Since FFAs are "tailor-made" to suit the needs of their users, they have become very popular with market participants wishing to hedge freight rate fluctuations (Kavussanos and Visvikis, 2003a, b).

In OTC derivatives markets each party accepts credit-risk (or counter-party risk) from the other party. The institutions that facilitate this market are major shipbrokers, investment banks, and other financial intermediaries in the fund management industry. The primary advantage of an OTC market is that the terms and conditions of the contract are tailored to the specific needs of the two parties. This gives investors flexibility by letting them introduce their own contract specifications in order to cover their specific needs. The OTC market allows its participants to quickly respond to changing needs and circumstances by developing new variations of old contracts.

The dry-bulk trading routes, which serve as the underlying assets of the FFA contracts today, are either from the Baltic Panamax Index (BPI (Table 11.1), the Baltic Capesize Index (BCI), the Baltic Supramax Index (BSI) or the Baltic Handysize Index (BHSI).[2] These indices comprise freight rates designed to reflect the daily movement in rates across dry-bulk spot voyage and time-charter rates.[3] Regarding wet-bulk trades, the underlying trading routes are from the Baltic Dirty Tanker Index (BDTI) and the Baltic Clean Tanker Index (BCTI). As can be seen in Table 11.1 for example, each (major) route included in these indices is given a number, which is recorded in the first column of the table. They refer to: vessel size (column 2); certain cargo (column 3); route description (column 4); while the weight assigned to each route is reported in the last column of the table. Each route is given an individual *weighting* to reflect its importance in the world-wide freight market at the time the index is constructed.

Table 11.1 Baltic Panamax Index (BPI) Composition, 2007

Routes	Vessel Size (dwt)	Cargo	Route Description	Weights
P1A_03	74 000	T/C	Transatlantic round voyage	25 %
P2A_03	74 000	T/C	Skaw-Gibraltar range to Far East	25 %
P3A_03	74 000	T/C	Japan – South Korea range to Pacific	25 %
P4_03	74 000	T/C	Far East to NOPAC South Korea pass	25 %
P1	55 000	Light Grain	US Gulf to Amsterdam, Rotterdam Antwerp (ARA) region	0 %
P2	54 000	HSS	US Gulf to Japan	0 %
P3	54 000	HSS	NOPAC to Japan	0 %

Notes:

- The vessel size is measured by its carrying capacity (dwt – deadweight tones) and includes the effective cargo, bunkers, lubricants, water, food rations, crew and any passengers.
- Routes P1A, P2A, and P3A and P4 refer to time-charter (T/C) contracts, while P1, P2, and P3 refer to voyage routes.
- HSS stands for Heavy Grain, Soya and Sorghum.

Source of data: Baltic Exchange.

[2] The detailed composition and description of the Baltic indices can be found at the website of the Baltic Exchange (www.balticexchange.com). The Baltic was formed in 1883 to bring together market participants wishing to buy and sell freight services. This physical pooling of participants in an organized market is equivalent, amongst other things, to pooling of information, which helps discover prices and contributes towards the efficient working of markets.

[3] Voyage charters are paid as freight in US$/ton to move goods from port A to port B and all costs paid by the shipowner. Time-Charters are paid as freight in US$/day, under which the shipowner earns hire every 15 days or every month. He operates the vessel under instructions from the charterer who pays voyage costs.

Provision is made so that the composition of the Baltic indices is altered over time, in line with developments in the sub-sectors of the shipping industry, in order to continue to reflect changing trading patterns. Specifically, at all times, the routes in the indices are chosen carefully by analysis of the percentage revenue value of the main commodities on the physical (spot) market, the total number and frequency of voyage fixtures by each commodity, and the balance of geographic origin and ton-mile contribution.

Since their introduction, FFA deals have grown substantially in both volume and value terms. Figures 11.1 and 11.2 show, respectively, the volume (number of contracts) and market value (in US$ billion) of dry-bulk FFA transactions, from inception until the end of 2006. The volume/value of trading has followed an exponential rise. The current growth of the FFA trades is expected to continue, with FFAs covering increasingly larger proportions of the underlying market. The exponential rise in FFA trading and the increasing liquidity and transparency of the market create increasing benefits to both shippers and direct customers, as well as intermediaries, such as forwarders and brokers.

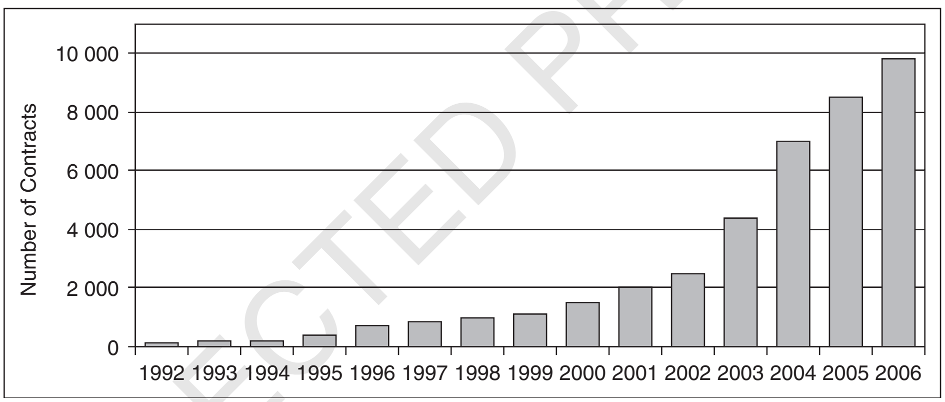

Figure 11.1 Yearly volumes of dry-bulk FFA contracts (Jan. 1992–Dec. 2006).
Source of data: Clarksons Securities Ltd.

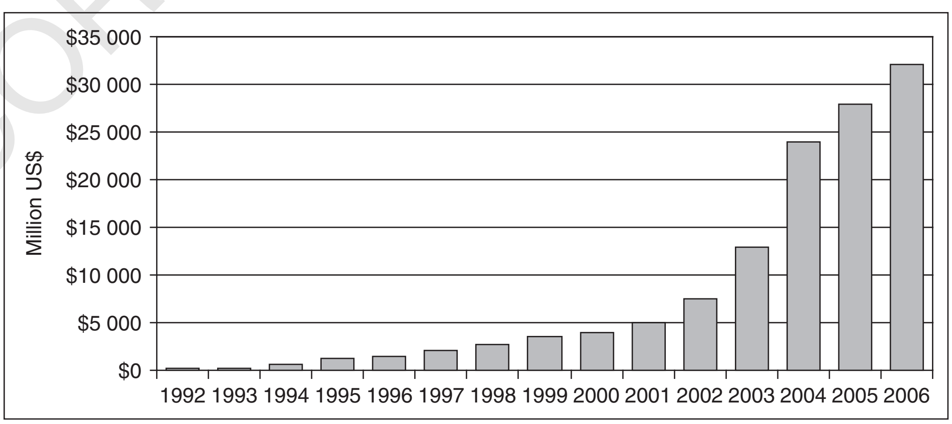

Figure 11.2 Yearly market values of dry-bulk FFA contracts (Jan. 1992–Dec. 2006).
Source of data: Clarksons Securities Ltd.

The following example illustrates their use. Assume that today is 25 September 2007 and that a charterer, which has to pay the cost of transporting his cargo of grain, believes that in one month (30 October 2007) freight rates in the trading route BPI, P2A (Skaw–Gibraltar range to Far East – 45 days) may increase from today's level of $78 000/day. In order to protect himself from a potentially more expensive market, he buys an FFA contract through his freight derivatives broker, in order to hedge his physical market exposure of $3 510 000 (= $78 000/day × 45 days). The broker will match this interest by finding another party, say a shipowner, which is the provider of the shipping service. The latter offers his Panamax vessel for hire, and anticipates that freight rates in the BPI P2A route may fall in one month from now. The shipowner will then sell an FFA, which expires in one month, at $78 000/day agreed today. Both parties, the shipowner and the charterer, would have locked their freight hire rate at $78 000/day.

To see this, assume that during 30 October 2007, the settlement price that is the average of the last seven business days prior to expiry is $91 000/day. As the freight market has increased, contrary to the expectations of the shipowner, the seller (shipowner) must pay $13 000/day (= $91 000–$78 000) to the buyer (charterer), which amounts to $585 000 (= $13 000/day × 45 days). Payment between the two parties is made by money transfer in US dollars within five business days following the settlement date. However, in the stronger physical (spot) market, the shipowner (charterer) gains (loses) $13 000/day, i.e., $585 000 more than he was expecting. Therefore, the net effect for both parties is that their cash-flows from the combined FFA–spot market portfolio were stabilized by locking in October's rates at $78 000/day.

In the dry-bulk market, voyage-based contracts are settled on the difference between the contracted price and the average prevailing value of the route selected in the index over the last seven working days of the settlement month. Time-charter-based contracts are settled on the difference between the contracted price and the average index value over the calendar settlement month. In the tanker market, a tanker FFA contract is an agreement between two parties to fix a freight rate in Worldscale units on a predetermined tanker route, over a voyage, at a mutually agreed price.[4] Settlement takes place at the end of each month, where the fixed forward price is compared against the monthly average of the spot price of the tanker route selected. If freight rates fall below the agreed rate, the charterer pays the difference between the agreed FFA price and the settlement spot price; if rates increase, then the charterer receives the difference.

11.3 FREIGHT FUTURES

The first freight derivatives product was the Baltic International Freight Futures Exchange (BIFFEX) contract, which was trading in the London International Financial Futures and Options Exchange (LIFFE) from May 1985 until April 2002. Its underlying asset was the index basket value of the Baltic Freight Index (BFI). However, the BIFFEX contracts did not produce overly effective hedges as discussed in Kavussanos (2002). The

[4] "Worldscale" was created in 1969 to assist the oil market have an independent unit of measurement of rates. Market levels of freight rates are expressed as a percentage of the scale rates instead of a plus or minus percentage. Worldscale rates are derived assuming that a "nominal" tanker functions on round voyages between designated ports. The calculated schedule rate (which equates to different US$/ton equivalents for each different route combination) is referred to as "Worldscale 100" or "Flat rate". Thus, Worldscale 100 means 100 points of 100 percent of the published rate or, in other words, the published rate itself.

unsatisfactory hedging effectiveness, the lack of liquidity towards the end of BIFFEX's life, coupled with the inception in 1992 of the OTC-traded FFA contracts, contributed to the decline in the volume of trading of BIFFEX contracts to levels which did not make it sustainable any more and during April 2002 LIFFE withdrew the contracts from its trading floor.

Since then, freight futures have been available in the organized exchanges of the International Maritime Exchange (IMAREX) in Oslo and the New York Mercantile Exchange (NYMEX) and are cleared in their associated clearing-houses. Clearing offers multilateral netting, removal of credit risk, standardised contracts, daily mark-to-market of positions and increase in trading liquidity. According to market sources, contract clearing has reached 25 % of the total freight derivatives trades as of July 2007. Clearing allows not only new shipping entrants but attracts non-shipping related companies as well (for example, steel mills, coal mines, energy houses and other companies in China, India and Japan). Other new participants coming into the market are banks, hedge funds (e.g. Castalia Fund Management Ltd., Clarkson Fund Management Ltd., Global Maritime Investments (GMI), etc.) and other financial institutions, resulting in a more sophisticated and liquid market.

11.3.1 Freight futures at the International Maritime Exchange (IMAREX)

IMAREX launched a complete marketplace for freight derivatives on 2 November 2001. Its initial focus was to establish a market for trading and clearing tanker freight derivatives. In mid-2002, its operations extended to the dry-bulk cargo sector. In partnership with the Norwegian Options and Futures clearing-house (NOS), IMAREX has become a regulated marketplace for trading and clearing freight derivatives.[5]

Trading for market participants can be facilitated directly on the IMAREX trading screen or via an authorized third-party freight derivatives broker (e.g. Clarksons, Simpson Spence & Young, Freight Investors Services, etc.). A potential trader on IMAREX can obtain either a direct membership account or get access to the IMAREX marketplace through a financial intermediary, called a General Clearing Member (GCM), which can be a shipping derivatives broker or a shipping lending bank. In a direct membership structure, principals enter into membership agreements with both IMAREX and NOS. On 18 December 2006, NOS expanded its clearing facilities for freight market investors by opening for clearing via GCMs. Customer segments at IMAREX include international shipping companies, energy companies, refineries, commodity and financial trading houses.

Table 11.2 presents the "Dirty" and "Clean" tanker freight futures (listed), FFAs (non-listed) and options (non-listed) contracts offered by IMAREX at the time of writing. Freight derivatives on other freight routes are also offered upon demand by negotiation, but do not appear on the table. As can be observed, the IMAREX derivatives products have as the underlying commodity (that they use for settlement) the route freight indices constructed by either the Baltic Exchange or Platts.[6] Market agents can select either contracts that are listed at IMAREX or non-listed contracts. Both are cleared through NOS.

[5] More information about IMAREX can be obtained at: www.imarex.com.

[6] Platts is a provider of energy news, price benchmarks, energy intelligence and decision-support services to the industry. It covers the petroleum, petrochemical, electricity, natural gas, coal, metals, nuclear power, bunker fuels and freight rate markets. Its products range from real-time news and pricing services to newsletters and magazines, market reports and in-depth studies, databases, electronic directories, and research services. Its customers include producers, traders, market-makers, refiners and analysts. More information about Platts can be obtained at: www.platts.com.

Table 11.2 IMAREX dirty and clean tanker derivatives, 2007

Routes	Sector	Route Description	Cargo Size (mt)	Cargo Size (barrels)	Type of Contract	Settlement Index
			Panel A: Dirty Tanker Derivatives			
TD3	VLCC	AG – East	260 000	1 925 000	Listed – Futures, Asian Option	Baltic
TD4	VLCC	West Africa – USG	260 000	2 002 000	Listed – Futures	Baltic
TD5	Suezmax	West Africa – USAC	130 000	1 001 000	Listed – Futures, Asian Option	Baltic
TD7	Aframax	North Sea – UK/Cont	80 000	616 000	Listed – Futures, Asian Option	Baltic
TD9	Aframax	Caribs – USG	70 000	539 000	Listed – Futures	Baltic
TD8	Aframax	AG – Singapore (FO)	80 000	616 000	Non-Listed – FFA	Baltic
TD10	Panamax	Caribs – USAC	50 000	385 000	Non-Listed – FFA	Baltic
TD12	Panamax	ARA – USG	55 000	423 500	Listed – Futures Non-Listed – FFA	Baltic
			Panel B: Clean Tanker Derivatives			
TC1	LR 2	AG – Japan	75 000	577 500	Listed – Futures	Platts
TC2	MR	Cont – USAC	37 000	254 100	Listed – Futures	Baltic
TC4	MR	Sing – Japan	30 000	231 000	Listed – Futures, Asian Option	Platts
TC5	LR 1	AG – Japan	55 000	423 500	Listed – Futures	Platts
TC6	MR	Algeria/Euromed	30 000	–	Listed – Futures	Baltic

Notes:
- LR 1 refers to Long Range Product Carriers between 55,000mt and 85,000mt.
- LR 2 refers to Long Range Product Carriers over 85,000mt.
- MR refers to Middle Range Product Carriers between 25,000mt and 55,000mt.
- The trading unit is Worldscale (WS) prices.

Source of data: IMAREX.

At the time of writing, there were four single-route freight futures contracts written on the dry-bulk routes produced by the Baltic Exchange. These are shown in Table 11.3, panel A. They involve the Capsesize voyage routes C4 and C7 and the Panamax time-charter routes P2A and P3A, as these routes attract most of the dry-bulk freight derivatives trading, both at IMAREX and in OTC markets. Besides the futures contracts written on the Baltic single route indices, Table 11.3, panel B shows the three time-charter "basket" futures contracts, which are listed and traded at IMAREX. These "baskets" of time-charter rates are constructed from the Baltic dry-bulk route indices of Capesize, Panamax and Supramax markets' routes. Thus, the four time-charter values of routes C8, C9, C10 and C11 of the BCI, are used to calculate CS4 T/C, representing the average time-charter rate that could be earned in the Capesize sector. Similarly, the average of the four Panamax time-charter routes (P1A, P2A, P3A and P4) of the BPI produces the PM4 T/C, while the SM6 T/C is the average of the six Supramax BSI routes (S1A, S1B, S2, S3, S4A and S4B).

Table 11.3 IMAREX single route and T/C "basket" dry-bulk derivatives, 2007

Routes	Sector	Route Description	Cargo Size (mt)	Type of Contract
		Panel A: Single Route Dry-Bulk Derivatives		
C4	Capesize	Richards Bay – Rotterdam	150 000	Listed – Futures
C7	Capesize	Bolivar – Rotterdam	150 000	Listed – Futures
P2A	Panamax	T/C Skaw Gibraltar – Far East	74 000	Listed – Futures
P3A	Panamax	T/C S.Korea – Japan Pacific R/V	74 000	Listed – Futures
		Panel B: T/C Basket Dry-Bulk Derivatives		
CS4 T/C	Capesize	Capesize T/C routes Average	172 000	Listed – Futures
PM4 T/C	Panamax	Panamax T/C routes Average	74 000	Listed – Futures
SM6 T/C	Supramax	Supramax T/C routes Average	54 000	Listed – Futures

Source of data: IMAREX.

11.3.2 Freight futures at the New York Mercantile Exchange (NYMEX)

Since 16 May 2005, the New York Mercantile Exchange (NYMEX) has offered nine tanker freight derivatives in its electronic trading platform. NYMEX is the world's largest physical commodity futures exchange and the trading forum for energy and precious metals.[7] Transactions executed on the exchange avoid credit risk because its clearing-house, ClearPort(sm), acts as the counterparty to every trade. They use as underlying commodities the Baltic Exchange or the Platts indices. Table 11.4 presents the specifications of the underlying indices; they are the five "dirty" tanker routes TD3, TD5, TD7, TD9 and TD10, shown in

Table 11.4 NYMEX listed dirty and clean tanker futures, 2007

Baltic Routes	NYMEX Coding	Sector	Route Description	Cargo Size (mt)	Type of Contract	Settlement Index
			Panel A: Dirty Tanker Futures			
TD3	TL	VLCC	Middle Eastern Gulf to Japan	260 000	Listed – Futures	Baltic
TD5	TI	Suezmax	West Africa – USAC	130 000	Listed – Futures	Baltic
TD7	TK	Aframax	North Sea – Europe	80 000	Listed – Futures	Baltic
TD9	TN	Panamax	Caribbean to US Gulf	70 000	Listed – Futures	Baltic
TD10	TO	Panamax	Caribbean to USAC	50 000	Listed – Futures	Baltic
			Panel B: Clean Tanker Futures			
TC1	TG	LR 2	Ras Tanura to Yokohama	75 000	Listed – Futures	Platts
TC2	TM	MR	Europe to USAC	37 000	Listed – Futures	Baltic
TC4	TJ	MR	Singapore to Japan	30 000	Listed – Futures	Platts
TC5	TH	LR 1	Ras Tanura to Yokohama	55 000	Listed – Futures	Platts

Source of data: NYMEX.

[7] More information about NYMEX can be obtained at: www.nymex.com.

panel A of the table, and the four "clean" tanker routes TC1, TC2, TC4 and TC5, presented in panel B of the same table.

11.4 "HYBRID" (CLEARED) FFAs

In response to demands from market participants to address the issue of credit risk present in OTC FFA contracts, a set of new derivatives contracts appeared. We call them "hybrid" FFAs, as they are OTC agreements, but cleared through a clearing house. Thus they maintain the flexibility of the FFAs and, for a fee, have credit risk eliminated through mark-to-market clearing, as in freight futures. These "hybrid" FFAs are cleared in the London Clearing House Clearnet (LCH.Clearnet) and in the Singapore Exchange AsiaClear (SGX AsiaClear).

11.4.1 Freight forwards at the London Clearing House Clearnet (LCH.Clearnet)

On 22 December 2003 the London Clearing House (LCH) Limited merged with Clearnet S.A. to form the "LCH.Clearnet" Group. On 13 September 2005, LCH.Clearnet launched a clearing and settlement platform for OTC FFAs. Potential members establish a relationship with a LCH.Clearnet clearing member for the management of margin and cash-flows, agreeing the commercial terms bilaterally, with the credit risk lying between the client and the clearing member. Alternatively, potential members can sign up to LCH.Clearnet as a clearing member.[8]

Table 11.5 presents the underlying indices upon which the freight forward contracts, which are cleared at LCH.Clearnet, are based. They include six tanker FFAs (crude and refined products), presented in panel A of the table; four dry-bulk voyage FFAs, presented in panel B; three "baskets" of dry-bulk time-charter FFAs, shown in panel C; and four dry trip time-charter FFAs, shown in panel D. In the tanker sector, forwards are written on the "dirty" TD3, TD5, TD7 routes and the "clean" TC2, TC4, TC5 routes. In the dry-bulk sector, FFAs are written on the Capesize voyage routes C3, C4, C5 and C7; on Capesize, Panamax, and Supramax time-charter "baskets"; and on the Panamax time-charter P2A and P3A routes and Capesize C4E and C7E routes.

11.4.2 Freight forwards at the Singapore Exchange AsiaClear (SGX AsiaClear)

In May 2006, Singapore Exchange Limited (SGX) launched SGX AsiaClear, its OTC clearing facility for energy and freight derivatives. In response to Asia's OTC market needs, SGX AsiaClear offers a network of Asia-based counterparties to facilitate OTC trading and clearing activities, to enhance credit and risk management and to increase OTC operations and position-netting efficiencies. The SGX AsiaClear facility provides immediate 20-hour central counterparty clearing for OTC FFAs. OTC market participants can conveniently use their OTC Inter-Dealer Brokers (IDBs) to register trades electronically on the SGX AsiaClear Trade Registration System for clearing and netting, under accounts maintained with SGX OTC Clearing Members. Clearing for the SGX AsiaClear facility is supported by the Singapore Exchange Derivatives Clearing Limited.[9]

[8] More information about LCH.Clearnet can be obtained at: www.lchclearnet.com.
[9] More information about SGX AsiaClear can be obtained at: www.asiaclear.com.sg.

Table 11.5 Listed forward contracts at LCH.Clearnet, 2007

Routes	Sector	Route Description	Cargo Size (mt)
		Panel A: Tanker Forwards	
TD3	VLCC	Middle Eastern Gulf to Japan	260 000
TD5	Suezmax	West Africa – USAC	130 000
TD7	Aframax	North Sea – USAC	80 000
TC2	MR	Continent to USAC	37 000
TC4	MR	Singapore – Japan	30 000
TC5	LR 1	ME – Japan	55 000
		Panel B: Dry Voyage Forwards	
C3	Capesize	Tubarao/Beilun and Baoshan	150 000
C4	Capesize	Richard Bay/Rotterdam	150 000
C5	Capesize	West Australia/Beilun-Baoshan	150 000
C7	Capesize	Bolivar/Rotterdam	150 000
		Panel C: Dry Time-charter Basket Forwards	
CTC	Capesize	Capesize 4 T/C routes Average	–
PTC	Panamax	Panamax 4 T/C routes Average	–
STC	Supramax	Supramax 5 T/C routes Average	–
		Panel D: Dry Trip Time-Charter Forwards	
P2A	Panamax	Skaw – Gibraltar/Far East	–
P3A	Panamax	Transpacific Round - Japan	–

Source of data: LCH.Clearnet.

Table 11.6 presents the underlying indices upon which the FFA contracts of SGX Asia-Clear are based. They include three tanker FFAs (crude and refined products), presented in panel A of the table; four dry voyage FFAs (dry-bulk commodities) presented in panel B; three "baskets" of dry time-charter FFAs, shown in panel C; and two dry trip time-charter FFAs, shown in panel D. In the tanker sector, FFAs are written on the "dirty" TD3 route and the "clean" TC4 and TC5 routes. In the dry-bulk sector, FFAs are written on the Capesize voyage routes C3, C4, C5 and C7; on Capesize, Panamax, and Supramax time-charter "baskets"; and on the Panamax time-charter P2A and P3A routes.

The development of allowing FFA contracts to be settled through a clearing-house in order to eliminate credit risk, is in response to calls from the industry. Potential market participants have always voiced their concern in relation to counterparty risk. These "hybrid" FFAs seem to combine the best of futures and forwards into one contract. That is, counterparty risk is removed and yet they retain their flexibility in terms of adjusting their terms according to the needs of the counterparties.

11.5 FREIGHT OPTIONS

Freight options contracts are available OTC on individual routes of the dry and tanker Baltic indices, as well as on baskets of time-charter routes, and are offered by the same derivatives brokers that trade FFA contracts and specialist investment banks (e.g. Macquarie Bank).

Table 11.6 Listed dirty and clean tanker forwards at SGX AsiaClear, 2007

Routes	Sector	Route Description	Cargo Size (mt)
		Panel A: Tanker Forwards	
TD3	VLCC	Middle Eastern Gulf to Japan	260 000
TC4	MR	Singapore to Japan	30 000
TC5	LR 1	Middle Eastern Gulf to Japan	55 000
		Panel B: Dry Voyage Forwards	
C3	Capesize	Tubarao/Beilun and Baoshan	150 000
C4	Capesize	Richard Bay/Rotterdam	150 000
C5	Capesize	West Australia/Beilun-Baoshan	150 000
C7	Capesize	Bolivar/Rotterdam	150 000
		Panel C: Dry Time-charter Basket Forwards	
CTC	Capesize	Capesize 4 T/C routes Average	–
PTC	Panamax	Panamax 4 T/C routes Average	–
STC	Supramax	Supramax 5 T/C routes Average	–
		Panel D: Dry Trip Time-Charter Forwards	
P2A	Panamax	Skaw – Gibraltar/Far East	–
P3A	Panamax	Transpacific Round - Japan	–

Source of data: SGX AsiaClear.

The Asian freight option contract is either a freight put option (floor) or a freight call option (cap). They settle the difference between the average spot rate over a defined period of time and an agreed strike price.[10] A shipowner anticipating falling freight rates will buy a put option, thus agreeing to sell his freight service in the future at a price agreed today. He would exercise the option to sell at the agreed price if the market freight rate falls below the agreed price, otherwise he will let the option expire worthless. On the other hand, a charterer would buy a call option, which he will exercise (to buy the freight service at the agreed price) if the market freight rate at expiry is higher than the agreed price. Both the charterer and the shipowner would pay a premium to purchase these options. In contrast to FFAs and freight futures, the downside cost is known in advance and is equal to the option's premium. The upside potential in a call option is unlimited, just as in the case of FFAs and freight futures. A detailed analysis of the various basic and advanced freight option strategies can be found in Kavussanos and Visvikis (2006a).

During 1 June 2005 the first cleared tanker IMAREX Freight Option (IFO) contract was launched, on route TD3 (AG – East, VLCC 260,000mt), cleared through NOS. The IFOs are available for trading and clearing for all IMAREX and NOS members and are structured as monthly call and put Asian style options, with monthly, quarterly and yearly maturities. During 2007, IMAREX announced IFO contracts on the following tanker routes: TD5 (West Africa – USAC), TD7 (North Sea – Continent), TC2 (Continent – USAC), TC4 (Singapore to Japan) and TC5 (AG – Japan) (see Panel A of Table 11.7). Moreover, dry-bulk

[10] An Asian option is an option that is exercised against an average over a period of time. Asian options are often used in thinly traded, volatile commodity markets to avoid problems with price manipulation of the underlying commodity near or at maturity. Freight markets fall into this category.

Table 11.7 IMAREX Asian Freight Options (IFO)

Routes	Sector	Route Description	Cargo Size (mt)
		Panel A: Tanker Asian IFOs	
TD3	VLCC	AG – East	260 000
TD5	Suezmax	West Africa – USAC	130 000
TD7	Aframax	North Sea – Continent	80 000
TC2	MR	Continent – USAC	33 000
TC4	MR	Singapore – Japan	30 000
TC5	LR 1	AG – Japan	55 000
		Panel B: Dry-Bulk Asian IFOs	
CS4TC	Capesize	T/C Average	–
PM4TC	Panamax	T/C Average	–
SM6TC	Supramax	T/C Average	–
C4 AVG	Capesize	Richards Bay – Rotterdam	150 000
C4	Capesize	Richards Bay – Rotterdam	150 000

Source of data: IMAREX.

IFOs have been launched on Capesize, Panamax and Supramax time-charter basket averages and on Capesize route C4 (see Table 11.7, Panel B).

Tanker and dry-bulk IFOs are settled against the Baltic Exchange quotes (with the exception of routes TC4 and TC5, where Platts assessments are used). More specifically, settlement prices for the tanker routes (measured in Worldscale points and 1 Lot = 1000mt), and the dry-bulk time-charter routes (measured in US$/day and 1 Lot = 1 Day) are calculated as the arithmetic average across all trading days in a calendar month and those for the dry-bulk voyage routes (measured in US$/ton and 1 Lot = 1000mt) are calculated as the arithmetic average of the spot prices over the number of Index days in the Delivery Period.

11.6 EMPIRICAL RESEARCH ON FREIGHT DERIVATIVES

Relatively limited research has been conducted on freight derivatives, in comparison with derivatives on other "commodities".[11] Part of the reason for this situation has been the lack of availability of data which could be used to support empirical work in these markets. Until recently, research work had to rely on primary data collected from freight derivatives brokers' records, often meeting the reluctance of agents in the "secretive" shipping industry to provide data and information for research. Currently, there are several derivatives exchanges, which collect those data and, for a fee, can make them available to interested parties.[12]

[11] Several empirical studies have examined the economic functions of the now redundant BIFFEX contract: Cullinane (1991, 1992) investigates the predictive power of short-term forecasts of the BFI by the use of the BIFFEX contract; Chang and Chang (1996) examine the predictability of BIFFEX with respect to the dry-bulk shipping market; Thuong and Visscher (1990), Haralambides (1992), Haigh and Holt (2002), and Kavussanos (2002) present studies that have examined the risk management function, through hedging, of the BIFFEX contract; Tvedt (1998) derives a pricing formula for European futures options in the BIFFEX market; Kavussanos and Nomikos (1999) and Haigh (2000) examine the unbiasedness hypothesis in the BIFFEX market using cointegration techniques.

[12] For an analytical survey of the recent empirical evidence that has appeared in economic studies relevant to freight derivatives see Kavussanos and Visvikis (2006b).

The success or failure of a derivatives contract is determined by its ability to perform its economic functions efficiently and, therefore, to provide benefits to economic agents over and above the benefits they derive from the spot market. Those economic functions that have attracted much research interest are price discovery and risk management through hedging. If the derivatives market does not perform one or both of these functions satisfactorily, then market agents have no reason to trade in the derivatives market, which eventually leads to loss of trading interest. Together with these important economic functions, research work has appeared in the literature on issues which include: the impact of the introduction of the FFA: markets on the volatility of the freight rates; the predictive power of freight derivatives prices; the relationship between FFA bid-ask spreads and expected volatility; the forward freight rate dynamics; the pricing of freight options; and the application of Value-at-Risk (VaR) models for measuring freight market risk. These are presented in Section 11.6.1.

11.6.1 Price discovery in freight derivatives

Following Working (1960), price discovery refers to the use of one price series (e.g. derivatives returns) for determining (predicting) another price series (e.g. spot returns). The lead-lag relationship between the price movements of derivatives returns and the underlying spot market returns illustrates how fast one market reflects new information relative to the other, and how well the two markets are linked.

A special feature of the freight derivatives market is that the underlying commodity is a service, which cannot be stored. The theory governing the relationship between spot and derivatives prices of continuously storable commodities is developed in Working (1960) amongst others, while that of non-storable commodities is examined in studies such as Eydeland and Geman (1998), Geman and Vasicek (2001), and Bessembinder and Lemmon (2002) in the electricity derivatives markets. The non-storable nature of the FFA market implies that spot and FFA prices are not linked by a cost-of-carry (storage) relationship, as in financial and agricultural derivatives markets. Thus, futures/forward prices on freight rates are driven by the expectations of market agents regarding the spot prices that will prevail at the expiry of the contract.

For a storable commodity, it is argued that the price of a forward contract, written on the commodity, must be equal to the spot price of the commodity today plus the financial and other costs (e.g. storage and insurance) to carry it forward in time. If this is not the case and the forward price is overpriced (underpriced), arbitrageurs/investors can simultaneously sell (buy) the forward contract, buy (sell) the underlying commodity and store it until the expiry of the contract. At expiry, reversing these positions will produce a risk-free profit. These movements by arbitrageurs ensure that correct prices always prevail in efficiently working markets, and they will be:

$$\mathrm{F}_{t,T} = \mathrm{S}_t + \mathrm{C}_{T-t} \tag{11.1}$$

where, $\mathrm{F}_{t,T}$ = price of a forward contract at time t, maturing at time period T; S_t = spot price of the underlying commodity in period t; and $\mathrm{C}_{T\text{-}t}$ = costs of carrying the commodity forward in time between period t and T.

There are, however, a number of factors that may lead to a large deviation of spot prices from derivatives prices, thus resulting in the existence of arbitrage opportunities. For instance, arbitrage opportunities may arise due to the existence of regional supply and demand imbalances, regulatory changes, market distortions created by market participants with large positions, etc. Therefore, the aforementioned relationship can be used to identify the existence of arbitrage opportunities in the market.

Kavussanos (2002) and Kavussanos and Visvikis (2004, 2006b) point out that freight services, as the underlying commodity of freight derivatives, are not storable. This violates the usual arbitrage arguments, presented above, that lead to the pricing of futures and forward contracts in storable commodities. In fact, in the above studies and in Kavussanos and Visvikis (2006b) it is shown that in this case, pricing of FFA and freight futures contracts takes the following form:

$$F_{t,T} = E(S_T) + u_t \quad ; \quad u_t \sim \text{iid}(0, \sigma^2) \tag{11.2}$$

where $F_{t,T}$ is the FFA price formed at period t for settlement at period T, $E(S_T)$ denotes the expected value of the spot (underlying) freight asset at the settlement date, and u_t is an independent and identically distributed stochastic error-term with a mean value of zero and variance σ^2. Provided the relationship is verified with actual data, it can be argued that the freight forward/futures market satisfies its price discovery functions. This is because futures or forward prices today can help discover spot prices in a future time period, specifically at the expiry of the derivatives contract. Thus, the identification of risk-less arbitrage opportunities in non-storable commodities, and therefore market efficiency, becomes a research issue.

In the spot (physical) market, several studies have investigated if time-charter rates are formed through expected spot rates, following the Expectations Hypothesis of the Term Structure (EHTS). Kavussanos and Alizadeh (2002) test the EHTS in the formation of time-charter rates and report rejection of the relationship, arguing that this is due to the existence of time-varying risk premiums, which moreover vary with the duration of the time-charter contract and with the vessel size. Adland and Cullinane (2005) reinforce these findings and show that the risk premium also varies with the market conditions. Alizadeh *et al*. (2007) examine if the implied forward 6-month time-charter rates in the dry-bulk freight market, which are derived through the difference between time-charters with different maturities based in the term structure model, are efficient and unbiased predictors of actual future time-charter rates. They report that implied forward rates are indeed unbiased predictors of future time-charter rates. However, despite the finding of unbiasedness, on average, chartering strategies based on technical analysis are able to generate economic profits.

Kavussanos *et al*. (2004) and Kavussanos and Visvikis (2004) investigate two different aspects of the price discovery function of the FFA market, namely the relationship between current forward prices and expected spot prices – embodied in the unbiasedness hypothesis, and the lead-lag relationship in returns and volatility between spot and forward prices, respectively. They examine the following constituent routes of the BPI: (a) the Atlantic voyage route P1 (US Gulf/Antwerp-Rotterdam-Amsterdam); (b) the Atlantic time-charter route P1A (Transatlantic round to Skaw-Gibraltar range); (c) the Pacific voyage route P2 (US Gulf/Japan); and (d) the Pacific time-charter route P2A (Skaw Passero-Gibraltar/Taiwan-Japan).

11.6.1.1 The unbiasedness hypothesis

According to the unbiasedness hypothesis, derivatives (futures/forward) contract prices must be unbiased estimators of spot prices of the underlying asset that will be realised at the expiration date of the contract. The existence of derivatives markets therefore can help discover prices which are likely to prevail in the spot market. Theoretically, a forward price is equivalent to the expected spot price at maturity, under the joint hypothesis of no risk-premium and rational use of information. The relationship can be tested empirically through the following equation:

$$\mathrm{S}_t = \beta_1 + \beta_2\ \mathrm{F}_{t,t-n} + \mathrm{u}_t \quad ; \quad \mathrm{u}_t \sim \mathrm{iid}(0, \sigma^2) \tag{11.3}$$

where $\mathrm{F}_{t,t-n}$ is the forward price at time $t-n$, for delivery at time t, S_t is the spot price at the maturity of the contract and u_t is a white noise error process. Unbiasedness holds when the following parameter restrictions $(\beta_1, \beta_2) = (0, 1)$ are valid.

Because most macroeconomic (time-series) variables are found to be non-stationary (they have a unit root) use of Ordinary Least Squares (OLS) to estimate Equation (11.3), result in inconsistent coefficient estimates and t- and F-statistics which do not follow standard distributions. The following Vector Error-Correction Model (VECM) cointegration framework, developed by Johansen (1988), is used instead to resolve the problem and reliably test for unbiasedness:

$$\Delta \mathrm{X}_t = \mu + \sum_{i=1}^{\mathrm{p}-1} \Gamma_i\, \Delta \mathrm{X}_{t-i} + \Pi \mathrm{X}_{t-1} + \mathrm{u}_t \quad ; \quad \mathrm{u}_t \sim IN(0, \Sigma) \tag{11.4}$$

where X_t is the 2×1 vector $(\mathrm{S}_t, \mathrm{F}_{t,t-n})'$, μ is a 2×1 vector of deterministic components which may include a linear trend term, an intercept term, or both, Δ denotes the first difference operator, u_t is a 2×1 vector of residuals $(\mathrm{u}_{S,t}, \mathrm{u}_{F,t})'$ and Σ the variance/covariance matrix of the latter. The VECM specification contains information on both the short- and long-run adjustment to changes in X_t, via the estimates of Γ_i and Π, respectively.

In the FFA market, Kavussanos *et al*. (2004) report that parameter restriction tests on the cointegrating relationship between spot and FFA prices indicate that FFA prices one- and two-month prior to maturity are unbiased predictors of the realised spot prices in all investigated routes. However, the efficiency of the FFA prices three-months prior to maturity gives mixed evidence, with routes P2 and P2A being unbiased estimators, and routes P1 and P1A being biased estimators of the realised spot prices. Thus, it is argued that unbiasedness depends on the market and type/length of contract under investigation. For the investigated routes and maturities for which unbiasedness holds, market agents can use the FFA prices as indicators of the future course of spot prices, in order to guide their physical market decisions.

Ishizaka *et al*. (2007) examine several factors determining equilibrium spot and futures/forward rates in shipping markets, assuming non-storability of freight rates. Based on the work of Tezuka and Ishizaka (2006), they extend the Bessembinder and Lemmon (2002) model to the freight market, which makes allowance for non-storability. In their study they take an equilibrium approach to derive futures/forward rates, rather than the cost-of-carry relationship. They construct a forward curve from wet-bulk sector (VLCC – AG/JP route) data, and examine the unbiasedness hypothesis. They use the futures curve in order to see if there are differences between the futures price and the expected value of the spot price at the maturity date (existence of risk-premiums) when market structures and conditions differ.

To specify the demand process, they use a Markov Regime Switching process model and assume a low demand situation and a high demand state. In their model it is assumed that the demand process can start either from a high or a low state and then change distribution at certain probability. Regarding the distribution of demand, the results show that when starting either from a high or a low state, it deviates from the state in which the process is at time 0. After observing the futures curve and risk-premium curve (biasness), which is the difference between the futures price and the expected value of the spot price at the maturity, the results indicate biasedness in all market conditions. Starting from a high demand state, futures curves tend to be upward sloping, but the risk-premium curves tend to be decreasing. On the other hand, starting from a low demand state the slopes of futures curves are downward, but the risk-premiums are upward. This may mean that in a high (low) demand period, market participants believe that the present (future) period is more important than future (present) periods and therefore, negative (positive) risk-premiums might exist for the future. Thus, it is suggested that the degree of biasedness depends on the initial demand conditions. Generally, in a high demand period, each participant values higher the present compared to any future period, and vice versa.

11.6.1.2 The lead-lag relationship

Kavussanos and Visvikis (2004) investigate the second dimension of the price discovery role of derivatives markets: that is, the lead-lag relationship between FFA and spot freight markets, both in terms of returns and volatilities. By using a VECM model (similar to that of Equation (11.4)), to investigate the short-run dynamics and the price movements in the two markets, causality tests and impulse response analysis indicate that there is a bi-directional causal relationship between spot and FFA prices in all routes, implying that FFA prices can be equally as important sources of information as spot prices. However, the results from causality tests on the unrestricted VECM models suggest that causality from FFA (spot) to spot (FFA) returns is stronger than in the other direction on routes P1 and P2A (on routes P1A and P2).

The finding that FFA markets informationally lead the underlying spot markets may be due to the fact that FFA trades are cash-settled deals, which require no chartering of vessel or movement of cargo, and therefore have lower transactions costs than the underlying/physical spot market. Furthermore, an investor can have an FFA contract on one or more of the trading routes for several time intervals, providing him ease of shorting. In contrast to FFA transactions that can be implemented immediately with no up-front cash, spot fixtures require greater initial costs and take longer to be completed. Therefore, market agents react to new information faster through the FFA market, in comparison to spot transactions. As a consequence, spot prices will lag behind FFA prices.

In order to investigate for volatility spillovers between the spot and FFA markets, an augmented bivariate VECM – Generalised Autoregressive Conditional Heteroskedasticity (GARCH) model is utilized, with the following positive definite parameterization of the variance-covariance matrix:

$$\begin{aligned} \mathrm{H}_t &= \mathrm{A}'\mathrm{A} + \mathrm{B}'\mathrm{H}_{t-1}\mathrm{B} + \mathrm{C}'\varepsilon_{t-1}\varepsilon'_{t-1}\mathrm{C} + \mathrm{S1}'\mathrm{u}_{1,t-1}\mathrm{u}'_{1,t-1}\mathrm{S1} \\ &\quad + \mathrm{S2}'\mathrm{u}_{2,t-1}\mathrm{u}'_{2,t-1}\mathrm{S2} + \mathrm{E}'(\mathrm{z}_{t-1})^2\mathrm{E} \end{aligned} \tag{11.5}$$

where A is a 2 × 2 lower triangular matrix of coefficients, B and C are 2 × 2 diagonal coefficient matrices, with $\beta_{kk}^2 + \gamma_{kk}^2 < 1$, k = 1,2 for stationarity, S1 and S2 are matrices which contain parameters of spillover effects, $\mathrm{u}_{1,t-1}$ and $\mathrm{u}_{2,t-1}$ are matrices whose elements are lagged square error-terms ($u_{1,t-1}$ represents the volatility spillover effect from the spot to the derivatives market and $u_{2,t-1}$ represents the volatility spillover effect from the derivatives to the spot market), $(z_{t-1})^2$ is the lagged squared basis, and E is a 1×2 vector of coefficients of the lagged squared basis. In this diagonal representation, the conditional variances are a function of their own lagged values (old news), their own lagged error terms (new news), volatility spillover parameters, and a lagged squared basis parameter, while the conditional covariance is a function of lagged covariances and lagged cross products of the ε_t's.

The results indicate that the FFA market volatility spills information to the spot market volatility in route P1. In route P1A the results indicate no volatility spillovers in either market. In routes P2 and P2A there is a bi-directional relationship as each market transmits volatility to the other. The previous results, in routes P1 and P2A, indicate that informed participants are not indifferent between trading in the FFA or in the spot market, as new market information is disseminated in the FFA market before the spot market. Thus, it seems that FFA prices for those routes contain useful information about subsequent spot prices, beyond that already embedded in the current spot price, and therefore can be used as price discovery vehicles, since such information may be used in decision-making. More specifically, market participants who have collected and analyzed new information regarding the expected level of spot and FFA prices in routes P1 and P2A, will prefer to trade in the forward market than in the spot market. Furthermore, the FFA contracts for routes P1, P2, and P2A contribute to the volatility of the relevant spot rate, and therefore further support the notion of price discovery. By explicitly modelling conditional variance dynamics, practitioners can have a clearer understanding of the price interactions in the spot and FFA markets. This can lead to a better assessment of risk management, ship-chartering and budget planning decisions.

11.6.2 Hedging effectiveness of freight derivatives

Derivatives markets exist in order to provide instruments for businesses to reduce or control the unwanted risk of price change by transferring it to others more willing to bear the risk. This function of derivatives markets is performed through hedging the spot position by holding an opposite position in the derivatives market. Kavussanos and Visvikis (2005) investigate the risk management function of the FFA market by examining the effectiveness of time-varying hedge ratios in reducing freight rate risk in the four aforementioned routes of the BPI. Comparison between the effectiveness of different hedge ratios is made by constructing portfolios implied by the computed ratios each week and then comparing the variance of the returns of these constructed (hedged) portfolios over the sample.

According to Johnson (1960) and Ederington (1979), the hedge ratio that minimises the risk of the spot position is given by the ratio of the covariance (measuring co-movement) between spot and derivatives price changes over the variance (measuring volatility) of derivatives price changes. The ratio is known as the Minimum Variance Hedge Ratio (MVHR). The MVHR methodology postulates that the objective of hedging is to minimise the variance of the returns in the hedge portfolio held by the investor. Therefore, the hedge ratio that generates the minimum portfolio variance should be the optimal hedge ratio. This is equivalent to the slope coefficient, $h*$, in the following regression:

$$\Delta S_t = h_0 + h^* \Delta F_t + \varepsilon_t;\ \varepsilon_t \sim \text{iid}(0, \sigma^2) \tag{11.6}$$

where $\Delta S_t = S_t - S_{t-1}$ is the logarithmic change in the spot position between $t-1$ and t; $\Delta F_t = F_t - F_{t-1}$ is the logarithmic change in the FFA position between $t-1$ and t, and $h*$

is the optimal hedge ratio. The degree of variance reduction in the hedged portfolio achieved through hedging is given by the coefficient of determination (R^2) of the regression, since it represents the proportion of risk in the spot market that is eliminated through hedging; the higher the R^2 the greater the effectiveness of the minimum variance hedge.

To account for the simultaneous estimation of spot and FFA prices and to allow for the time variation in h^*, VECM-GARCH are used in in- and out-of-sample tests. They indicate that, in voyage routes P1 and P2, the relationship between spot and FFA prices is quite stable and market agents can use simple first-difference regression models in order to obtain optimum hedge ratios. In contrast, on time-charter routes P1A and P2A, it seems that the arrival of new information affects the relationship between spot and FFA prices, and therefore time-varying hedging models should be preferred. Also the hedging effectiveness varies from one freight market to the other. This is because freight prices, and consequently FFA quotes, are affected by different regional economic conditions. Market agents can benefit from this result by developing appropriate hedge ratios for each route, and thus controlling their freight rate risk more effectively.

11.6.3 The impact of freight derivatives trading on spot market price volatility

Derivatives markets can be seen to be enhancing economic welfare by allowing for new positions, expanding investment sets, providing instruments for reducing risks and enabling existing positions to be taken at lower costs. However, the issue of whether derivatives trading increases or reduces volatility in the spot market has been the subject of considerable empirical analysis and has received the attention of policymakers.

Kavussanos *et al.* (2004) investigate the impact of FFA trading on spot market price volatility of the four aforementioned routes of the BPI, by employing a GARCH model modified along the lines of the GJR-GARCH model of Glosten *et al.* (1993). This allows for the asymmetric impact of news (positive or negative) on volatility. Thus, the mean equation of the GJR-GARCH process is defined as follows:

$$\Delta \mathrm{S}_t = \varphi_0 + \sum_{i=1}^{p-1} \varphi_{\mathrm{i}} \Delta \mathrm{S}_{t-i} + \varepsilon_t \quad ; \quad \varepsilon_t \sim \mathrm{I}N(0, \mathrm{h}_t) \tag{11.7}$$

where S_t is the natural logarithm of the daily spot price change, Δ is the first-difference operator and ε_t is the regression error-term, which follows a conditional normal distribution with mean zero and time-varying covariance, h_t. The conditional variance of the process is specified as follows:

$$\mathrm{h}_t = \mathrm{a}_0 + \mathrm{a}_1 \mathrm{h}_{t-1} + \beta_1 \varepsilon_{t-1}^2 + \gamma_1 \varepsilon_{t-1}^2 \mathrm{D}_{t-1}^- \tag{11.8}$$

where D_{t-1}^- is a dummy variable that takes the value of unity if the error is negative ($\varepsilon_{t-1}^{<0}$) and zero otherwise. When the coefficient of D_{t-1}^- is zero (i.e. $\gamma_1 = 0$), the model of Equation (11.8) is the symmetric GARCH model. A negative shock ($\mathrm{D}_{t-1}^- = 1$) can generate an asymmetric response on volatility, in comparison to a positive shock. When $\gamma_1 > 0$ ($\gamma_1 < 0$), the model produces a larger (smaller) response for a negative shock compared to a positive shock of equal magnitude. *A priori* one expects a positive sign for the γ_1 coefficient, as there is evidence in the literature which shows that bad news has a larger impact on price volatility than good news.

The impact of the onset of FFA trading is examined in two ways. First, the model of Equation (11.8) is estimated for the period before and after the onset of FFA trading and the estimated coefficients in the two models are compared. Thus, the asymmetry of the relationship between information and volatility before and after the onset of FFA trading may be inferred through the value of the estimated coefficient γ_1 before and after FFAs. Secondly, in order to examine how the onset of FFA trading has affected volatility, a dummy variable (D_1) is introduced (with a coefficient γ_2) in the variance equation representing the time period before and after FFA trading. A significant positive γ_2 coefficient indicates increased unconditional spot price volatility in the post-FFA period, whereas a significant negative γ_2 coefficient indicates decreased unconditional spot price volatility in the post-FFA period.

The results suggest that the onset of FFA trading has (i) reduced the spot price volatility of all investigated routes; (ii) a decreasing impact on the asymmetry of volatility (market dynamics) in routes P2 and P2A; and (iii) substantially improved the quality and speed of information flow for routes P1, P1A and P2. These findings have several implications for the way in which the FFA market is viewed. It appears that there has been an improvement in the way that news is transmitted into prices following the onset of FFA trading. It is argued that by attracting more, and possibly better informed, participants into the market, FFA trading has assisted the incorporation of information into spot prices more quickly. Thus, even those market agents who do not directly use the FFA market have benefited from the introduction of FFA trading.

11.6.4 The predictive power of freight derivatives

Batchelor *et al*. (2007) test the performance of several time-series models (multivariate Vector Autoregressive – VAR; VECM; Seemingly Unrelated Regressions Estimation – SURE-VECM; and univariate Autoregressive Integrated Moving Average – ARIMA) in predicting spot and FFA rates on P1, P1A, P2 and P2A freight routes of the BPI.

Univariate ARIMA (p, d, q) models of the following form are used to generate forecasts of spot and FFA prices:

$$\Delta S_t = \mu_{1,0} + \sum_{i=1}^{p} \mu_{1,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{1,j} F_{t-j} + \varepsilon_{1,t} \quad ; \quad \varepsilon_{1,t} \sim iid(0, \sigma_1^2) \qquad (11.9a)$$

$$\Delta F_t = \mu_{2,0} + \sum_{i=1}^{p} \mu_{2,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{2,j} F_{t-j} + \varepsilon_{2,t} \quad ; \quad \varepsilon_{2,t} \sim iid(0, \sigma_2^2) \qquad (11.9b)$$

where ΔF_t and ΔS_t are changes (first-differences) in log FFA and spot prices respectively, and $\varepsilon_{k,t}$; $k = 1,2$, is a white noise random error-term. For an ARIMA (p, d, q) model the terms p, d, q refer to the lagged values of the dependent variable, the order of integration and the lagged values of the error-term respectively, in the specification of the model.

The bivariate VAR(p) model of the following form is also used to produce forecasts of spot and FFA prices in a simultaneous spot-FFA framework:

$$\Delta S_t = \mu_{1,0} + \sum_{i=1}^{p} \mu_{1,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{1,j} F_{t-j} + \varepsilon_{1,t} \tag{11.10}$$

$$\Delta F_t = \mu_{2,0} + \sum_{i=1}^{p} \mu_{2,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{2,j} F_{t-j} + \varepsilon_{2,t} \quad ; \quad \varepsilon_{k,t} \sim iid(0, \sigma_k^2)$$

Finally, the unrestricted and restricted versions of the bivariate VECM(p) model of the following form is used to generate simultaneous out-of-sample forecasts for spot and FFA prices:

$$\Delta S_t = \mu_{10} + \sum_{i=1}^{p} \mu_{1,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{1,j} F_{t-j} + \alpha_1 (S_{t-1} - \beta_1 F_{t-1} - \beta_0) + \varepsilon_{1,t} \tag{11.11}$$

$$\Delta F_t = \mu_{20} + \sum_{i=1}^{p} \mu_{2,i} \Delta S_{t-i} + \sum_{j=1}^{q} \gamma_{2,j} F_{t-j} + \alpha_2 (S_{t-1} - \beta_1 F_{t-1} - \beta_0) + \varepsilon_{2,t}$$

$$\varepsilon_{i,t} | \Omega_{t-1} \sim IN(0, \mathrm{H})$$

where the term in brackets represents the cointegrating (long-run) relationship between the spot and FFA prices. The error-terms follow a normal distribution with mean zero and covariance matrix, H.

Independent non-overlapping forecast sets are created by generating N-period ahead multiple forecasts, from recursively estimated model parameters. The results indicate that while conditioning spot returns on lagged FFA returns generates more accurate forecasts of spot prices for all forecast horizons (up to 20 days ahead), conditioning FFA returns on lagged spot returns enhances forecast accuracy only up to four days ahead. For longer forecast horizons, simple univariate ARIMA models seem to be the best models for forecasting FFA prices. Thus, FFA prices can enhance the forecasting performance of spot prices and, consequently, by selecting the appropriate time-series model for forecasting purposes, market participants can design more efficient investment and speculative trading strategies.

On the other hand, it seems that spot prices cannot help in enhancing the forecasting performance of FFA prices, which indicates that the forward rate does contain significantly more and different (and maybe better) information than is embodied in the current spot rate. The implication of this is that even if market participants do not use the FFA market for hedging reasons, by collecting and analyzing FFA prices they can obtain “free” information about the future direction of spot freight prices.

11.6.5 Microstructure effects in freight derivatives markets

Transactions costs are an important consideration in investors’ investment decisions. One such significant cost is the Bid-Ask Spread (BAS). Brokers match buy and sell contracts and the price charged for this service is known as the BAS; that is, the difference between the buying (bid) and selling (asked) price per contract. This normally is regarded as compensation to brokers for providing liquidity services in a continuously traded market. There should be a positive relationship between the BAS and price volatility on the grounds that the greater the variability in price, the greater the risk associated with performance of the function of the brokers. Intuitively, unambiguous *good* or *bad* news regarding the fundamentals of the price of the asset should have no systematic effect on the spread. However, greater uncertainty regarding the future price of the asset, as associated with greater volatility of the price of the asset, is likely to result in a widening of the spread.

Batchelor *et al*. (2005) examine the relationship between expected volatility and bid-ask spreads in the FFA market using the four aforementioned routes of the BPI. In order to derive an estimate of the FFA volatility, the following AR(p)-GARCH(1,1) model is employed:

$$\Delta F_t = \varphi_0 + \sum_{i=1}^{p-1} \varphi_i \Delta F_{t-i} + \varepsilon_t \;\; ; \;\; \varepsilon_t \sim \text{iid}(0, h_t) \;\; ; \;\; h_t = a_0 + a_1 h_{t-1} + \beta_1 \varepsilon_{t-1}^2 \qquad (11.12)$$

where F_t is the natural logarithm of FFA prices (average mid-point of the bid-ask quotes), Δ is the first-difference operator, and ε_t is a white noise error-term with mean zero and time-varying variance, h_t.

One-step ahead conditional volatility estimates (h_{t+1}), derived from the above model are used to analyze the relationship between expected volatility and current BAS_t. Specifically, the BASs are regressed against variables that represent risk, information and a lagged BAS, as in the following equation:

$$BAS_t = \beta_0 + \beta_1 h_{t+1} + \beta_2 BAS_{t-1} + \beta_3 \Delta F_t + u_t \;\; ; \;\; u_t \sim \text{iid}(0, h_t) \qquad (11.13)$$

where risk is captured by the one-step ahead conditional volatility (h_{t+1}) from a GARCH(1,1) model, information effects are accounted for by the logarithmic first-difference of the FFA price series (ΔF_t) and BAS_t is defined as the difference of the natural logarithm of the ask quote minus the natural logarithm of the bid quote [$\ln(Ask_t) - \ln(Bid_t)$]. The model is estimated via the Generalized Method of Moments (GMM), thus avoiding any simultaneity bias and yielding heteroskedasticity and autocorrelation consistent estimates.

The results indicate that there is a positive relationship between bid-ask spreads and expected price volatility for routes P1, P2, and P2A. In contrast, on route P1A there is no significant relationship between bid-ask spreads and expected volatility. This finding may be explained by the thin trading of FFA contracts for the latter route. The results can provide a better understanding of the movements of FFA prices, and the consequent effect on transactions costs. Market participants using information on the behaviour of bid-ask spreads have a better insight into the timing of their FFA transactions and the future direction of the FFA market, as a widening bid-ask spread corresponds to an anticipation of increased future volatility.

11.6.6 Market surveys on the use of freight derivatives

Dinwoodie and Morris (2003) survey the attitudes of tanker shipowners and charterers towards freight hedging and their risk perceptions of FFAs. The survey includes questionnaire replies from seven countries over 22 shipowners and eight charterers. They argue that although FFAs were widely viewed as an important development, some respondents were unaware of their function and the majority had not used them. Most of the participants in this survey were concerned about the risk of payment default on settlement. Many shipowners also feared that FFAs might expose their risk management policies to counterparties. The link between freight hedging activity and participants' risk aversion was not clear-cut, but they argue that improved "technical" education is essential for widespread acceptance.

Kavussanos *et al*. (2007) explore the importance of hedging through a questionnaire survey of 31 Greek shipping counterparties. The general attitudes and common perceptions of the use of shipping derivatives by Greek shipowners involved in both dry-bulk and tanker trades are investigated. The results indicate that: (i) risk management and shipping derivatives are at an early stage of development and understanding in the Greek shipping market, although participants in the sample seem to know about them; (ii) the traditional ways of thinking must be changed and replaced with modern risk management concepts, which should form part of the overall business strategy of the company; (iii) liquidity and credit (counterparty) risk are considered to be major obstacles in the use of shipping derivatives; (iv) in line with the findings of Dinwoodie and Morris (2003), they consider education to be of paramount importance for them; and finally, (v) there seems to be a positive view of the future of shipping derivatives in Greece, especially if the banks endorse them.

11.6.7 Forward freight rate dynamics

Koekebakker and Adland (2004) investigate the forward freight rate dynamics by modelling them under a term-structure model. They transform time-charter rates into average based forward freight rates. They then assume that there exists a continuous forward freight rate function that correctly prices the average based forward freight rate contracts. For their analysis, they use time-charter rates for a Panamax 65 000 dwt vessel under three different time-charter maturities: six-months, one-year and three years. These data are then used to construct, each day, a forward rate function using a smoothing algorithm in order to investigate the factors governing the dynamics of the forward freight rate curve. Results indicate that the volatility of the forward curve is bumped, with volatility reaching a peak for freight rates with roughly one year to maturity. Moreover, correlations between different parts of the term-structure are in general low and even negative. They conclude that these results are not found in other markets. Such a forward freight rate model provides a tool to perform freight rate derivatives valuation and hedging.

Adland *et al*. (2007) investigate the volatility structure of the forward freight rate function in the route-specific tanker freight futures market using IMAREX quarterly and calendar year freight futures contracts. They argue that knowledge of the volatility structure is important when pricing freight options and when measuring the market risk inherent in the freight derivatives portfolio. The framework of Heath, Jarrow and Morton (HJM, 1992) is followed for modeling the continuous forward freight rate function that provides the price today for freight at any given point of time in the future. This is derived empirically using a smoothing algorithm for each trading day in the sample. They report a volatility structure that is increasing over a horizon of several weeks and then sharply declining in the time to maturity of the contracts. It is suggested that this is a reflection of the expected short-term positive autocorrelation and long-run mean reversion of tanker spot freight rates. It is further reported that while the volatility of short-term forward freight rates is increasing in the vessel size, the annualized volatility of forward freight rates across sizes is converging, at a maturity of around one year. However, the authors argue that the empirical results must be interpreted with caution, as the freight futures market in general remains illiquid compared to other commodity markets.

11.6.8 Pricing of freight options

Tvedt (1998) estimates an analytical formula for pricing European futures options on BIFFEX. The following assumptions are made: Due to the possible lay-up of vessels, the underlying index of BIFFEX, namely the BFI, is never close to zero. Therefore, it is assumed that the BFI, and also the futures price process, are restricted downwards by an absorbing level, which is above zero. Further, it is assumed that freight rates are mean reverting, due to frictional capacity adjustments to changes in the demand for shipping services. These properties influence the valuation of options contracts on BIFFEX.

Let λ be an absorbing level for the BFI process that would be the lay-up level for vessels. Assuming that the BFI less the absorbing level λ is log-normally distributed, then the increment of the index is given by the following mean reversion process:

$$\mathrm{dX}_t = \mathrm{k}[\mathrm{a} - \ln(\mathrm{X}_t - \lambda)](\mathrm{X}_t - \lambda)\mathrm{d}_t + \sigma(\mathrm{X}_t - \lambda)\mathrm{dZ}_t \tag{11.14}$$

where X_t is the index value (BFI) at time t, dZ_t is the increment of a standard Brownian motion, and k, a and σ are constants. Generally, the futures price at time t (Φ_t) is the expected value at time t of the spot price at the time of settlement T. Following Black (1976), in the case of no risk-premium from investing in the futures market, it is argued that the futures price process is given by the expectation of the spot process at the time of settlement. Therefore, the futures price process is given by:

$$\mathrm{d}\Phi_t = e^{-\mathrm{k}(T-t)}\sigma(\Phi_t - \lambda)\mathrm{dZ}_t \tag{11.15}$$

where the weight $e^{-k(T-t)}$ determines the degree by which the volatility in the spot rate (the BFI) is transferred over to the futures price process. Tvedt (1998) argues that since BFI is an index of prices of shipping services, and since a service cannot be stored, the cost-of-carry argument does not apply. Consequently, he argues that mean reversion in prices can prevail without being smoothed out by storage and can be explained without referring to changes in inventory costs.

The present value of a European call option on a BIFFEX futures at time t is given by the expectation of the value of the option at settlement date (C_T):

$$\mathrm{C}_T = e^{\mathrm{r}(T-t)}\mathrm{E}[(\Phi_t - \psi)\chi_{\mathrm{A}}] \tag{11.16}$$

where r is a constant risk-free interest rate, χ_{A}isthe indicator function of the event A (that is, the option is only exercised when it is favourable for the option holder) and ψ is the strike price. Calculating Equation (11.17), using traditional arbitrage arguments and assuming no transactions costs or taxes, the value of a European option on a futures contract in the BIFFEX market was derived as:

$$\mathrm{C}_T = e^{-\mathrm{r}(T-t)}[(\Phi_t - \lambda)\mathrm{N}(\mathrm{d}_1) - (\psi - \lambda)\mathrm{N}(\mathrm{d}_2)] \tag{11.17}$$

where,

$$\mathrm{d}_1 = \frac{\ln\left(\frac{\Phi_t - \lambda}{\psi - \lambda}\right) + \left[1/2\, e^{-2k(T-t)}\sigma^2(T-t)\right]}{e^{-k(T-t)}\sigma\sqrt{T-t}}, \mathrm{d}_2 = \frac{\ln\left(\frac{\Phi_t - \lambda}{\psi - \lambda}\right) - [1/2\, e^{-2k(T-t)}\sigma^2(T-t)]}{e^{-k(T-t)}\sigma\sqrt{T-t}}$$

Koekebakker *et al.* (2007) propose a mathematical framework for Asian freight options modeling, which is an extension of the framework put forward in Black (1976). Under this theoretical framework, the spot freight rate at time t, which is a non-traded asset, is denoted $S(t)$. A future arithmetic average of S consists of N fixings at time points $T_1 < T_2 < \ldots < T_N$. An FFA contract with a price $F(t, T_1, T_N)$ can be interpreted as the price set today at time t to deliver at time T_N the value of the arithmetic average of the underlying spot freight rate during the period $[T_1, T_N]$. Moreover, an FFA is a cash-settled contract that gives the difference between this average and the price $F(t, T_1, T_N)$ multiplied by a constant D.[13] They show that the value of an FFA can be found by discounting this cash-flow received at time T_N and taking the conditional expectation under the pricing measure Q. Rearranging and solving for the FFA price, it is simply the expected average spot price under the pricing measure:

$$F(t, T_1, T_N) = \frac{1}{N}\sum_{i=1}^{N} E_{\mathrm{t}}^{Q}[S(T_{\mathrm{i}})]. \tag{11.18}$$

It is argued that FFAs are lognormal prior to the settlement period, but this lognormality breaks down in the settlement period. They suggest an approximate dynamics structure in the settlement period for the FFA, leading to closed-form option pricing formulas for Asian call and put options written on the spot freight rate indices. Using Equation (11.19), the payoff of a call Asian option with strike price K and maturity $T \leqslant T_N$ is derived as:

$$D\left[\frac{1}{N}\sum_{i=1}^{N} S(T_i) - K\right]^{+} = D[F(T, T_1, T_N) - K]^{+} \tag{11.19}$$

and for a put

$$D\left[K - \frac{1}{N}\sum_{i=1}^{N} S(T_i)\right]^{+} = D[K - F(T, T_1, T_N)]^{+}. \tag{11.20}$$

Given that freight options relate to periods that are non-overlapping multiples of the monthly settlement period, they are caps and floors. Thus, the price at time $t < T_N$ for a call option is derived as:

$$C(t, T_N) = e^{-r(T_N - t)} D(F(t, T_1, T_N)\, N(d_1) - K\, N(d_2)) \tag{11.21}$$

where $d_1 = \frac{\ln\left(\frac{F(t,T_1,T_N)}{K}\right) + \frac{1}{2}\sigma_F^2}{\sigma_F}$, $d_2 = d_1 - \sigma_F$, and $N(\mathrm{x})$ is the standard cumulative normal distribution function.

[13] The constant D refers to the number of calendar days covered by the FFA contract or an agreed cargo size for time-charter routes and voyage route, respectively.

For the put option, the put-call parity for futures contracts combined with the symmetry property of the normal distribution is used to derive:

$$P(t, T_N) = e^{-r(T_N - t)} D(K\, N(-d_2) - F(t, T_1, T_N)\, N(-d_1)). \tag{11.22}$$

The authors conclude that other stochastic specifications of the spot freight rate process may be more appropriate. For instance, extensions of this work should incorporate the term-structure of volatility that exists due to mean reversion in the spot freight rate process and the possible existence of seasonal volatility.

11.6.9 Measuring freight market risk

An important question in the sector is when to utilize derivative products to hedge freight rate risks. To that effect, Kavussanos and Dimitrakopoulos (2007) introduce and formalize a market risk measurement and management framework for the shipping business. Two alternative risk metrics are proposed: Value-at-Risk (VaR) and Expected Shortfall (ES). VaR is a single, summary, statistical number that expresses the maximum expected loss over a given time horizon, at a certain confidence interval and for a given position or portfolio of instruments, under normal market conditions.

Defining the continuously compounded return of an asset as $r_t = \ln(P_t/P_{t-1})$ for the period from $t-1$ to t and letting r_t follow the stochastic process $r_t = \mu_t + z_t\, \sigma_t$ (where, $\mu_t = E(r_t)$ is the conditional mean and σ_t^2 is the conditional variance) VaR denotes the maximum loss over a predefined investment horizon (e.g. one day), that can be sustained at a certain confidence level $(1 - \alpha)$. Mathematically:

$$F(VaR_{t+1}^{1-a}) = P(r_t \leqslant VaR_{t+1}^{1-a}) = a. \tag{11.23}$$

VaR has been criticized for its inability to quantify and express the loss beyond the VaR level and for not being a coherent risk metric.

The ES is defined as the expected value of the loss beyond the VaR level (shortfall), under the condition that a shortfall occurs and fulfils the coherency conditions required for risk metrics:

$$ES = E_t(r_t | r_t < VaR_{t,a}). \tag{11.24}$$

Kavussanos and Dimitrakopoulos (2007) provide an evaluation assessment of alternative VaR and ES forecasting models for short- and medium-term freight risk exposures for the tanker shipping sector. More specifically, freight market risk exposures corresponding to vessel portfolios, employed to routes of the Baltic Clean Tanker Index (BCTI) and Baltic Dirty Tanker Index (BDTI) or to single vessels employed in individual routes are considered.[14] The alternative modeling approaches include: variance modeling approaches (such as the random walk, the GARCH and exponentially weighted moving average specifications); simulation based approaches (such as the historical simulation, the exponential historical simulation,

[14] Individual routes used include: TD3 (Middle East Gulf to Japan, for vessel sizes of 250 000dwt), TD5 (West Africa to USAC, for vessel sizes of 130 000 dwt), TD7 (North Sea to Continent, for vessel sizes of 80 000 dwt) and TD9 (Caribbean to US Gulf, for vessel sizes of 70 000 dwt.

the filtered historical simulation and Monte Carlo);[15] and semi-parametric approaches (such as the extreme value methods).[16] Each of the alternative VaR specifications is evaluated in terms of statistical accuracy (or statistical sufficiency in the concept of interval forecast evaluation) and regulatory performance (regulatory loss functions, penalizing large deviations of VaR and ES values from realized losses, are used).

The results indicate that unhedged positions in routes TD3 and TD9 are found to be more risky than positions in the other markets examined (TD5 and TD7). The comparative analysis of the alternative VaR and ES forecasting models indicates that the GARCH and the Historical or the Filtered Historical Simulation approaches perform best for forecasting short-term (daily) risk. On the other hand, the most reliable method for estimating long-term risk exposures is the empirically scaled historical simulation model. Thus, it is suggested that both the VaR and the ES risk metrics, if employed correctly, may contribute to an effective management of freight risk.

Besides the aforementioned study, two other empirical studies try to measure freight market risk with the use of the VaR methodology. Angelidis and Skiadopoulos (2007) apply several parametric and non-parametric VaR methods in dry-bulk (Baltic Dry Index, the 4 Time-Charter Average BPI and the 4 Time-Charter Average BCI) and wet-bulk (Dirty Tanker TD3 route) markets. They argue that the simplest non-parametric methods can be used to measure freight market risk and that the freight rate risk is greater in the wet-bulk market. Lu *et al*. (2007), using index data from the dry-bulk market (BCI, BPI and BHMI), find the General Error Distribution (GED) Exponential E-GARCH-VaR model to be able to efficiently measure market risk.

11.7 CONCLUSION

This chapter presented how freight derivative instruments, such as futures, forwards and options, can be used to hedge freight rate risks in the dry- and wet-bulk sectors of the shipping industry. It started by presenting the underlying indices of freight rate derivatives, which are constructed by the Baltic Exchange. These indices and their constituent routes provide the underlying commodities for freight rate derivatives to be written upon. Then exchange-traded, OTC and cleared-OTC freight derivatives were analyzed. It can be argued that freight derivatives can provide the flexibility that traditional methods of risk management are not able to provide to shipping companies.

Furthermore, the economics underlying the freight derivatives markets and the empirical research evidence related to them have been outlined. In general, it has been shown that: (i) freight derivatives contracts serve their price discovery function well, as FFA prices are unbiased predictors of future spot rates and FFA markets informationally lead, in terms of returns and volatilities, the underlying spot markets; (ii) FFA contracts serve their risk

[15] In the non-parametric **historical simulation**, the next period's returns are well approximated by the empirical distribution of the last m-observations. In the **exponential historical simulation**, heavier weights are assigned to more recent observations in the available historical m-observation data window. In the **filtered historical simulation**, GARCH modelling is combined with the historical simulation method. In the **Monte Carlo simulation**, GARCH modelling is combined with simulation of standardized pseudo-random normal variables that are used in conjunction with volatility forecasts in order to generate price paths.

[16] According to the extreme value method of filtered peaks over threshold, a generalized Pareto distribution is fitted to excesses over a high threshold of standardized residuals by means of a maximum likelihood technique in order to obtain quantile estimators.

management function through hedging; (iii) the existence of freight derivatives markets have reduced spot market volatility and the informational asymmetries in the spot market; (iv) market participants, by collecting and analyzing FFA prices, can obtain "free" information about the future direction of spot freight prices, as FFA prices can assist in forecasting spot prices; (v) VaR and ES methods can be utilized to provide meaningful and accurate risk forecasts, leading to consistent and effective management of freight risk; and (vi) the volatility structure of the forward freight rate function in the freight futures market and pricing formulas for freight options have been examined. Obviously, there is a lot more work that can be carried out in our effort to understand better the fundamentals of freight derivatives markets. However, this chapter can form a basis upon which further work in the area can develop.

11.8 REFERENCES

Adland, R. and K. Cullinane (2005). A Time-varying Risk Premium in the Term Structure of Bulk Shipping Freight Rates. *Journal of Transport Economics and Policy* **39**(2): 191–208.

Adland, R., S. Koekebakker and S. Sodal (2007). Forward Curve Dynamics in the Tanker Futures Market. In: *Conference Proceedings of the 17th International Association of Maritime Economists (IAME)*, Athens, Greece, 4–6 July 2007.

Alizadeh, A. H., R. Adland and S. Koekebakker (2007). Predictive Power and Unbiasedness of Implied Forward Charter Rates. *Journal of Forecasting*, **26**(6), 385–403.

Angelidis, T. and G. Skiadopoulos (2007). Measuring the Market Risk of Freight Rates: A Value-at-Risk Approach. In: *Conference Proceedings of the 17th International Association of Maritime Economists (IAME)*, Athens, Greece, 4–6 July 2007.

Batchelor, R., A. H. Alizadeh and I. D. Visvikis (2005). The Relation between Bid-Ask Spreads and Price Volatility in Forward Markets. *Derivatives Use, Trading & Regulation* **11**(2): 105–125.

Batchelor, R., A. H. Alizadeh and I. D. Visvikis (2007). Forecasting Spot and Forward Prices in the International Freight Market. *International Journal of Forecasting* **23**: 101–114.

Black, F. (1976). The Pricing of Commodity Contracts. *Journal of Financial Economics* **3**: 167–179.

Chang, Y. and H. Chang (1996). Predictability of the Dry-Bulk Shipping Market by BIFFEX. *Maritime Policy and Management* **23**: 103–114.

Cullinane, K. P. B. (1991). Who's Using BIFFEX? Results from a Survey of Shipowners. *Maritime Policy and Management* **18**: 79–91.

Cullinane, K. P. B. (1992). A Short-Term Adaptive Forecasting Model for BIFFEX Speculation: A Box-Jenkins Approach. *Maritime Policy and Management* **19**: 91–114.

Dinwoodie, J. and J. Morris (2003). Tanker Forward Freight Agreements: The Future for Freight Futures. *Maritime Policy and Management* **30**(1): 45–58.

Ederington, L. (1979). The Hedging Performance of the New Futures Markets. *Journal of Finance*. 157–170.

Eydeland, A. and H. Geman (1998). Pricing Power Derivatives. *RISK* **11**, October: 71–73.

Geman, H. and O. Vasicek (2001). Plugging into Electricity. *RISK* **14**, August: 93–97.

Glosten, L. R., R. Jagannathan and D. Runkle (1993). On the Relation between the Expected Value and the Volatility of the Nominal Excess Return on Stocks. *Journal of Finance* **48**: 1779–1801.

Haigh, M. S. (2000). Cointegration, Unbiased Expectations and Forecasting in the BIFFEX Freight Futures Market. *Journal of Futures Markets* **20**(6): 545–571.

Haigh, M. S. and M. T. Holt (2002). Hedging Foreign Currency, Freight and Commodity Futures Portfolios. *Journal of Futures Markets* **22**(12): 1205–1221.

Haralambides, H. E. (1992). Freight Futures Trading and Shipowners Expectations. Conference Proceedings, *6th World Conference on Transport Research*, Lyon, France. Les Presses De L'Imprimerie Chirat 2: 1411–1422.

Heath, D., R. Jarrow and A. Morton (1992). Bond Pricing and the Term Structure of Interest Rates: A New Methodology for Contingent Claim Valuation. *Econometrica* **60**(1): 77–105.

Ishizaka, M., K. Tezuka and M. Ishii (2007). A Study on Shipping Freight Futures Curves in an Equilibrium Market Model. In: *Conference Proceedings of the 17th International Association of Maritime Economists (IAME)*. Athens, Greece, 4–6 July 2007.

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control* **12**: 231–254.

Johnson, L. L. (1960). The Theory of Hedging and Speculation in Commodity Futures. *Review of Economic Studies* **27**: 139–151.

Kavussanos, M. G. (2002). Business Risk Measurement and Management in the Cargo Carrying Sector of the Shipping Industry. In: *The Handbook of Maritime Economics and Business*, Lloyds of London Press, Chapter 30: 661–692.

Kavussanos, M. G. and A. H. Alizadeh (2002). The Expectations Hypothesis of the Term Structure and Risk-Premia in Dry-Bulk Shipping Freight Markets; An EGARCH-M Approach. *Journal of Transport Economics and Policy* **36**(2): 267–304.

Kavussanos, M. G. and D. N. Dimitrakopoulos (2007). Measuring Freight Risk in the Tanker Shipping Sector. In: *Conference Proceedings of the 17th International Association of Maritime Economists (IAME)*. Athens, Greece, 4–6 July 2007.

Kavussanos, M. G. and N. K. Nomikos (1999). The Forward Pricing Function of Shipping, Freight Futures Market. *Journal of Futures Markets* **19**(3): 353–376.

Kavussanos, M. G. and I. D. Visvikis (2003a). Financial Derivative Contracts in the Shipping Industry and the Price Discovery Function of Freight Forward Agreements (FFA). *Lloyd's Shipping Economist (LSE)*, February.

Kavussanos, M. G. and I. D. Visvikis (2003b). FFAs can Stabilize Revenue. *Lloyd's Shipping Economist (LSE)*, July.

Kavussanos, M. G. and I. D. Visvikis (2004). Market Interactions in Returns and Volatilities between Spot and Forward Shipping Markets. *Journal of Banking and Finance* **28**(8): 2015–2049.

Kavussanos, M. G. and I. D. Visvikis (2005). The Hedging Performance of Over-The-Counter Forward Shipping Freight Markets. In: *Conference Proceedings of the 14th International Association of Maritime Economists (IAME)*, Izmir, Turkey, 30 June–2 July 2004.

Kavussanos, M. G. and I. D. Visvikis (2006a). *Derivatives and Risk Management in Shipping*. Witherbys Publishing.

Kavussanos, M. G. and I. D. Visvikis (2006b). Shipping Freight Derivatives: A Survey of Recent Evidence. *Maritime Policy and Management* **33**(3): 233–255.

Kavussanos, M. G. and I. D. Visvikis (2007). Derivatives in Freight Markets. *Special Report Commissioned by Lloyd's Shipping Economist*, A Lloyd's MIU Publication, Informa Business, London, November 2007.

Kavussanos, M. G., I. D. Visvikis and R. Batchelor (2004). Over-The-Counter Forward Contracts and Spot Price Volatility in Shipping. *Transportation Research – Part E, Logistics and Transportation Review* **40**(4): 273–296.

Kavussanos, M. G., I. D. Visvikis and M. A. Goulielmou (2007). An Investigation of the Use of Risk Management and Shipping Derivatives: The Case of Greece. *International Journal of Transport Economics* **XXXIV**(1): 49–68.

Kavussanos, M. G., I. D. Visvikis and D. A. Menachof (2004). The Unbiasedness Hypothesis in the Freight Forward Market: Evidence from Cointegration Tests. *Review of Derivatives Research* **7**(3): 241–266.

Koekebakker, S. and R. Adland (2004). Modelling Forward Freight Rate Dynamics – Empirical Evidence from Time Charter Rates. *Maritime Policy and Management* **31**(4): 319–336.

Koekebakker, S., R. Adland and S. Sodal (2007). Pricing Freight Rate Options. *Transportation Research – Part E, Logistics and Transportation Review* **43**(5): 535–548.

Lu, J., F. Wei and H. Want (2007). Value-at-Risk on Dry Bulk Shipping Freight Index. In: *Conference Proceedings of the 17th International Association of Maritime Economists (IAME)*, Athens, Greece, 4–6 July 2007.

Tezuka, K. and M. Ishizaka (2006). Equilibrium Spot and Futures Price Formulae and Numerical Calculation of Biasness in Shipping Markets. *Journal of Logistics and Shipping Economics* (in Japanese), **40**: 115–124.

Thuong, L. T. and S. L. Visscher (1990). The Hedging Effectiveness of Dry-Bulk Freight Rate Futures. *Transportation Journal* **29**: 58–65.

Tvedt, J. (1998). Valuation of a European Futures Option in the BIFFEX Market. *Journal of Futures Markets* **18**(2): 167–175.

Working, H. (1960). Price Effects of Futures Trading. Reprinted in A. E. Peck (Ed.) (1997) *Selected Writings of Holbrook Working*. Chicago: Chicago Board of Trade, 45–75.