Erasmus University Rotterdam

MSc in Maritime Economics and Logistics (MEL)

2010/2011

Chartering Strategies for Oil Companies

By

Jessica Chia-Chi Wang

Acknowledgements

This thesis is to summarize my previous four-year tanker chartering works and one-year master study. Sincere gratitude to those who guided me, supported me, or have been with me during the time.

Thanks to my thesis supervisor, Mr. J. P. M. Lafranca, who enthusiastically supported me by bringing this idea into reality and provided much guidance and precious opinions.

I would also like to express my appreciation for my colleagues and my friends in the tanker industry who generously shared with me the data and their expertise, and inspired me in many ways, especially Joseph Milon, David J Saginaw, James Gundy, Ann Bee, Stanley Shih, and Jeff Chen.

In addition, special thanks to Carlos, my professional thesis editor, and my dear classmates in MEL who made my life in MEL unforgettable.

Last but definitely not least, thanks for the divine love and the abundant grace from the Lord Jesus Christ, the support from my dear husband Joseph, the genuine love and care from my sister in the Lord Weiyu and all the dear brothers and sisters in Church in Delft. I would not have finished this work without you. Thank you all.

Abstract

This paper discusses the general chartering strategy trends for oil companies and provides a systematic approach for strategic tanker chartering decisions focusing mainly on the shipping contract mix problem. To analyze trends in chartering strategies, this thesis categorizes oil companies from an oil supply chain perspective into four main categories; integrated oil companies, oil producers, oil consumers, and oil traders in order to identify different levels of involvement in crude oil transport and composition of shipping contracts. In terms of contract mix analysis, Modern Portfolio Theory and a non-linear model are introduced as the main methodology to analyze the optimal shipping contract mix. A contract mix case from an Asian based oil company is then provided utilizing introduced theories and models to find the optimal shipping contract mix.

Table of Contents

List of Tables

List of Figures

1. Introduction

1.1 Background

The tanker market plays a critical role in the supply chain distribution for oil companies and generally involves billions of dollars worth of freight bills every year. Shipping rates, however, can be volatile with oil companies standing to benefit from substantial freight rate savings when there is oversupply of tonnage or facing unexpected loss when the market turns in favour of shipowners. Given the importance of maritime transport for oil companies, managing this freight rate volatility is of crucial importance for oil companies. This paper therefore analyzes the role of chartering strategy as a means of mitigating freight rate volatility and applies portfolio theory to create an optimal crude oil shipping contract mix for oil companies aimed at not only minimizing freight rate volatility but also managing other shipping risks. This thesis will focus on chartering strategies for long-haul, crude oil transport; chartering decisions for other petrochemicals such as LNG, LPG, and refined products are therefore beyond the scope of the research presented herein.

1.2 Objective

The objective of this thesis is to find the optimal solution for balanced long-term contracts and spot market chartering. In the light of the aforementioned objective, this thesis is structured around the following research question:

How should an oil company choose an optimal shipping contract mix which serves the company's strategic chartering target?

To address the research question, the paper will firstly seek to highlight the importance of tanker chartering for oil companies by discussing the chartering strategies for different categories of oil companies, and provide an understanding of the factors which influence chartering decisions. It will then use quantitative methods to analyze the shipping contract mix.

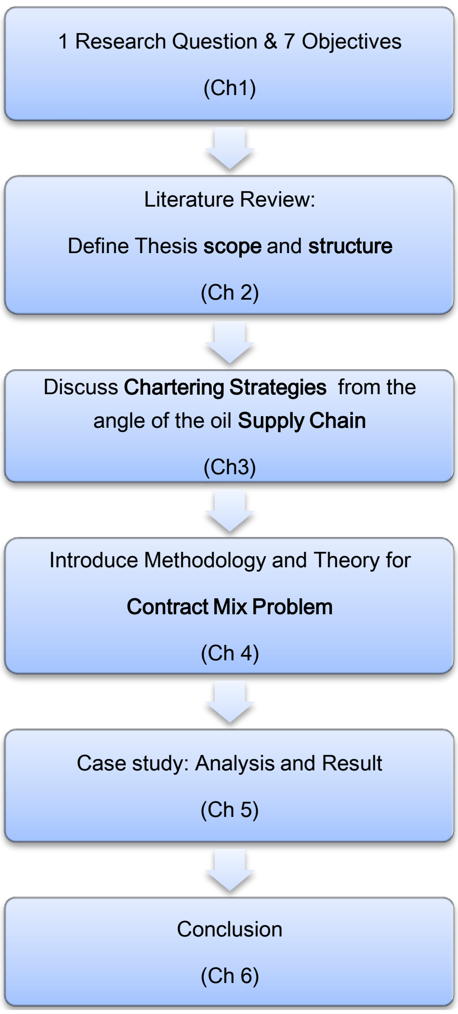
In the light of the research question, this thesis seeks to achieve the following objectives:

1. Highlight the importance of the tanker chartering business for oil companies;
2. Identify the level of participation in crude oil transport for different oil companies;
3. Discuss the chartering strategies for different categories of oil companies;
4. Provide an understanding of the factors influencing chartering decisions;
5. Provide an understanding of the mechanics of risk diversification in Markowitz's Modern Portfolio Theory;
6. Apply Modern Portfolio Theory to the shipping contract mix problem; and
7. Model the shipping contract mix and obtaining efficient portfolio configuration.

1.3 Thesis Outline

This thesis begins with Chapter 2 which provides the literature review for this study, placing the thesis within the larger context of the existing literature on this subject. Chapter 3 introduces the multiple functions of crude oil transportation and presents the patterns of participation in crude oil transportation and chartering strategies for oil companies by categorizing oil companies according to different core businesses in the supply chain. The chartering characteristics of each type of oil company are highlighted in order to derive the key factors influencing the chartering strategies. Chapter 4 introduces the theory and methodology namely the coverage ratio and portfolio theory in preparation for the shipping contract mix case study in Chapter 5. To provide an applicable chartering strategy tool, a spreadsheet-based non-linear programming model according to modern portfolio theory is elaborated to support the decision of optimal mix of period and voyage-based contracts for oil companies. The thesis closes with Chapter 6 which provides an overview of the main conclusions derived from this study.

Figure 1: Thesis flowchart

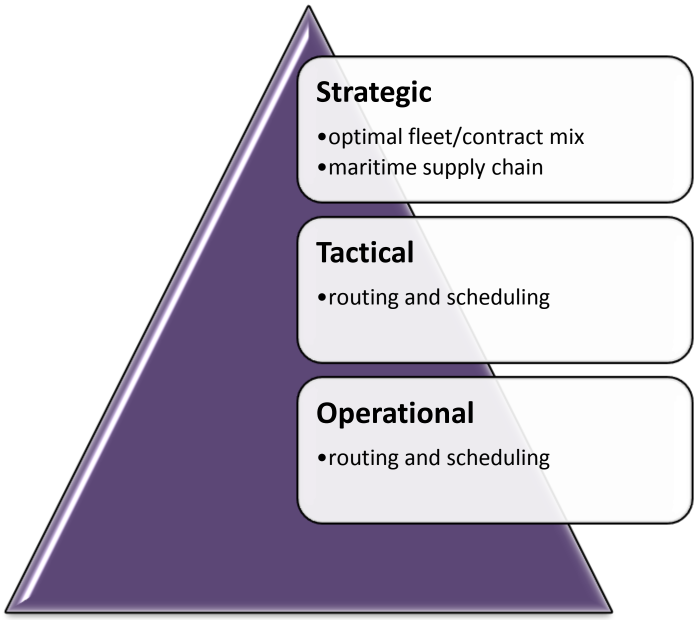


2. Literature Review

According to the studies by Lawrence (1972), Christiansen et al. (2004, 2007), and Fagerholt et al. (2009) shipping operations can be classified into three modes based on different business models: Industrial, tramp, and liner. In industrial shipping, the shipper controls the fleet and aims to minimize transport costs. In tramp shipping, the shipper and carrier are independent units. The carrier enters into shipping contracts with shippers to carry bulk cargoes within a fixed time frame; the primary goal is profit maximization. In liner shipping, the carrier designs a set of routes and operates the transport business based on a regular voyage schedule. Industrial shipping is comparable to “owning a car”, tramp shipping to “a taxi service”, and liner shipping to “a bus service” with published routes and schedules.

Christiansen et all (2004, 2007) took another step by classifying decade long shipping operational research literature into three segments according to planning level: strategic, tactical, and operational planning. These three levels are not mutually exclusive. Instead, the decisions among the three levels are often correlated and linked. In the strategic level, Christiansen et all (2004) highlighted that an optimal fleet mix and maritime supply chain are two crucial strategic planning problems to be discussed. At the tactical and operational planning levels, routing and scheduling are the main issues to be addressed. Among the three levels, tactical planning and operational planning have gained moderate attention over the last decade. However, there has been little research on strategic shipping planning (e.g., optimal contract mixes and maritime supply chain).

Figure 2: Shipping operation research literatures based on planning levels



On the strategic planning level, Taylor (1981) addressed the fleet combination problem and indicated that the best chartering portfolio policies result in the highest income in a number of different market conditions. Fagerholt et all (2009) applied both optimization-based methods and simulation methods to approach fleet size and mix problems for tramp and industrial shipping. In addition to operational research and statistic methods, financial approaches have also been applied to the shipping planning problems. Berg-Andressen (1998) applied classical portfolio theory (Markowitz, 1952) and designed a risk and return model to optimize mixed fleet and routes for an independent bulk owner. Shen and Vogiatzis (2004) as well as Ansari (2007) extensively discussed the application of portfolio theory and capital asset pricing model on shipping companies. Yet, strategic shipping operational issues from oil companies' perspective are highly under-researched.

Based on the aforementioned literature, this study falls within the category of the strategic planning level in shipping operational research and aims to discuss the two strategic issues: the patterns of chartering strategies for oil companies analyzed from the perspective of oil supply chain (Chapter 3) and shipping contract mix patterns and modeling (Chapter 4 and 5), as categorized by Christiansen et al. (2004). Furthermore, different from most of the previous studies emphasizing the strategic decisions for carriers, this study approaches strategic shipping planning issues from the angle of oil companies, the shippers in the tanker business.

3. Chartering Strategies for Oil Companies

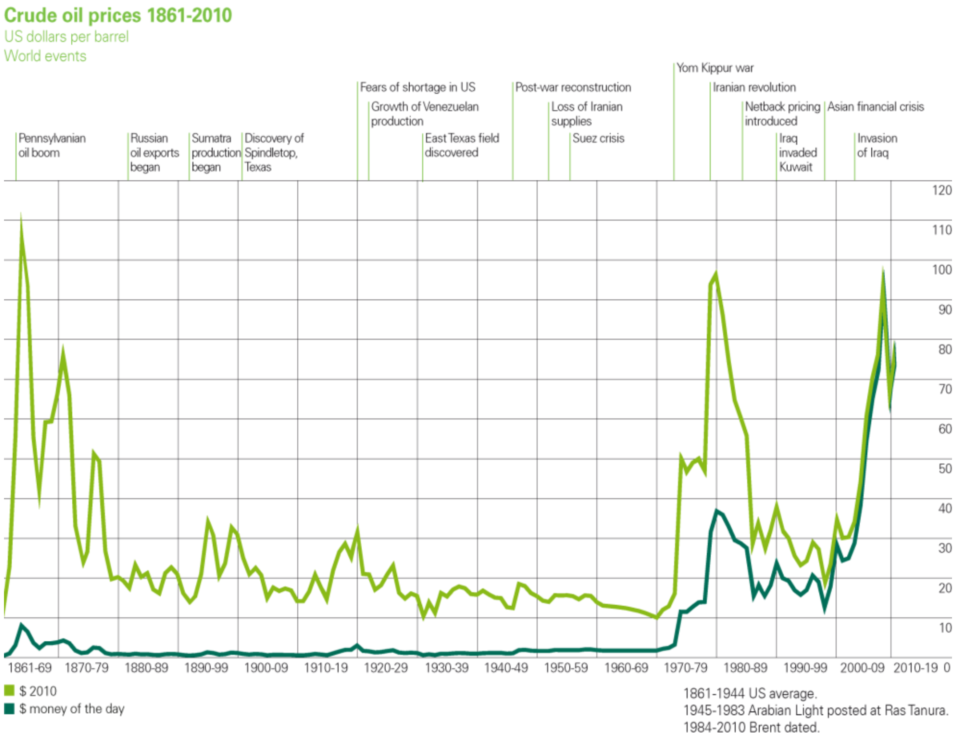
Crude oil transportation is the process of transporting crude oil from producing fields to the facilities where it is refined. It is the central operation between the upstream and downstream function of the oil industry. (Cheng & Duran, 2004) As a critical process in oil industry, most of the oil companies have a certain level of participation in the process. Some oil companies have limited involvement yet still need to negotiate shipping terms and nominate tankers to load ports and discharging ports while most integrated oil companies have developed sophisticated logistics with regard to crude oil transportation. The latter have invested substantial human and infrastructure resources committed to the process. The commitment includes owned vessels, seafaring personnel, terminal investment, substantial contracting of period and spot transportation, vetting operations, and various shore-side organizations.

In this chapter we present the full spectrum of different levels of oil companies' participation in crude oil transportation, and discuss the patterns of chartering strategies based on empirical evidence. The fundamental considerations with regard to chartering strategies are thus generalized.

3.1 The Function of Crude Oil Transportation for Oil Companies

The oil price and the freight cost for one barrel of crude oil from the Middle East Gulf to Western Europe both remained steady at around USD 1.00 until the first oil crisis in 1970s. Marine transport accounted for half of the total CFR (Cost and Freight) cost per barrel and was thus considered strategically crucial for oil companies (Stopford, 2010). Most oil majors, in order to secure crude oil transportation, had at least 50% proprietary fleets. They played dual roles as both shippers and carriers in terms of crude oil transportation. The oil crises of 1973 and 1979 led to increasing oil price volatility (Fig. 3). Despite the fact that the oil crises of the 1970s led to higher oil prices, crude oil transportation costs were not significantly affected due to scale economies and advanced technology leading to more efficient maritime transport. Typical long-haul crude oil transport costs remained in the range of USD 1.50 to USD 3.00 per barrel of crude (Cheng and Duran, 2004) whereas the price of crude oil per barrel is no longer within the single digit range.

Figure 3: Crude Oil Prices 1861-2010



Source: BP Statistical Review of World Energy, 2011

Since freight rates nowadays account for a marginal single-digit percentage of the total CFR costs, the business of crude oil transportation should have become less relevant. Evidence, however, reveals that most integrated oil companies still regard crude oil transport as a strategically important process since crude oil transportation serves multiple functions in their business. These companies either maintain a significant percentage of controlled fleets, or set up professional marine divisions or independent subsidiaries in order to maintain control of the crude oil transport. The patterns are especially true with regard to global oil giants such as Shell, ExxonMobil, Chevron, Total, and BP.

Function: Transport, Storage, Oil Trading Facilitating

The oil industry supply chain contains eight different stages from upstream exploration to downstream distribution and marketing (Fig. 4).Most refining facilities are closer to consumption areas rather than to production areas. Due to the geographical imbalance of crude oil production and refinery, the most important function of crude oil transportation is to deliver crude oil to refineries for producing petrochemical products.

Figure 4: Supply Chain for Oil Industry

Besides carrying crude oil from production to refinery, crude oil transport plays two other crucial functions, namely providing flexible storage capacity and facilitating oil trading. In terms of storage, oil companies consider crude oil in-transit as part of their inventory (in-transit inventory) no matter which shipping term is applied in sale and purchase contracts. (Table 1: Shipping terms in crude oil sale and purchase contracts,p14) If the land-based storage capacity is full, oil companies could either instruct vessels to sail at lower speeds or defer the discharging operation so as to keep the crude oil on board a bit longer thus creating a temporary buffer for land-based storage capacity. Though companies are required to bear more costs, either demurrage/detention for a voyage charter or extra hire and bunker costs for a time charter, most companies are pleased to have such an option of floating tanks, since the land-based storage tanks are subject to scarce land and limited flexibility.

Another crucial function the process serves is to facilitate crude oil trading business. Though most trading is done for the purpose of hedging, crude oil trading in a future market will eventually involve the process of transferring the physical product from the sellers to the buyers. Therefore oil traders need to be involved in the crude oil transportation business in case that a parcel of traded cargo is actually lifted. For instance, the contract of Brent crude oil requires the seller to deliver a notice 15 days prior to the physical lifting. Once a lifting date has been scheduled for a trading cargo, this cargo is known as a dated cargo with a specific lifting date attached. The ultimate buyer of this cargo will need to lift it by the lifting date. (Clubley, 1998)

The multiple functions served by the process of crude oil transportation in the supply chain as presented above coincide with the empirical evidence that most oil companies still consider this business essential to their operations. The following sections will therefore describe the different levels of oil company participation in crude oil transport and will analyze the various chartering strategies.

3.2 Oil companies' Participation in Crude Oil Transportation

Oil company involvement in crude oil transport can be categorized as either passive or active; from fully outsourcing crude oil transport to operating the process in-house. Oil companies therefore have multiple chartering strategy options depending on their preferred business model.

3.2.1 Passive Participation vs. Active Participation

At one end of the spectrum, an oil company purchasing crude oil may choose to passively participate in crude oil transport by fully outsourcing crude oil transport to its counterparty. In this case however, the oil company still needs to negotiate shipping terms in the sale and purchase contract; examining whether the ships arranged by the seller fulfill the vetting requirements of the terminals and of the receivers. At the other end of the spectrum, a company may decide to thoroughly enter into crude oil seaborne transport business. This business model then requires the company to have **commercial**, **operational**, and even **technical** activities associated with marine transport. Apart from daily commercial activities such as scheduling, ship chartering, and freight invoicing, the company actively participating in crude oil transportation may stretch its business to operational activities, such as vessel manning, crew repatriation, catering, storing and bunkering, and furthermore to technical activities, such as vessel maintenance, voyage and shipyard repairs, and spare parts purchasing.

The paragraphs hereunder categorize and define the levels of oil companies' participation in crude oil transport from fully outsourcing to in-house operation based on two criteria: the shipping terms found in crude oil sale and purchase contracts and shipping contracts. The types of contracts which oil companies enter into reflect their level of participation in the seaborne oil transport business.

3.2.2 Shipping Terms in Crude Oil Sale and Purchase Contracts

Four types of shipping terms regulated by Incoterms (International Commercial Terms) are used for the sale and purchase contracts where transportation is entirely conducted by water. The terms are as follows:

FAS – Free Alongside Ship (named loading port)
Free Alongside Ship refers to the transfer of goods from the seller to the buyer alongside a ship at a named loading port. The goods being provided by the seller must be cleared by customs. Risk is transferred to the buyer once the goods are placed at the designated place at the named loading port. This shipping term is suitable only for maritime transport but not for multimodal sea transport in containers (Incoterms 2010). It is also not common in oil cargo sea transport since oil is pumped out from the pipelines connected to seller's storage facilities either on-shore or off-shore. It is difficult to define the meaning of "alongside ship" when loading oil cargoes. This term is therefore is typical for heavy-lift or dry bulk cargo.

FOB – Free on board (named loading port)

Free on board refers to the transfer of goods being cleared by the seller to the buyer on board the ship nominated by the buyer with cost and risk divided at ship's rail. This shipping term is also only suitable for pure maritime transport therefore not including multimodal sea transport in containers (Incoterms 2010). Since freight is not included in FOB, the buyer who agrees this shipping term must arrange the transportation on its own.

CFR – Cost and Freight (named destination port)

Cost and Freight means that the seller is responsible for the costs and freight of bringing goods to the port of destination, whereas insurance is at the responsibility of the buyer. Though the seller must arrange the transportation, the risk is transferred to the buyer once the goods are loaded on the ship. This shipping term is also only suitable for pure maritime transport.

CIF – Cost, Insurance and Freight (named destination port)

Under the shipping term the seller is responsible for the costs, insurance, and freight of bringing goods to the port of destination. CIF shipping term is the same as CFR except that under CIF the seller must pay for insurance.

FOB is the most common shipping term in crude oil sale and purchase contracts; while in petrochemical product sale and purchase contracts, FOB, CFR, and CIF are all quite common. The different shipping terms used in crude oil and petrochemical product contracts are caused by the different patterns in the marine transport. In terms of crude oil transport, shipping arrangement for the buyer is comparably easy. Generally a crude oil parcel is a full-ship loaded quantity with no specific requirement with regard to heating when loading and transporting and no strictly defined specifications. Furthermore, there is often a quite efficient shipping market (either spot or term) for most crude oil seaborne routes. Therefore FOB is common since the buyer could undertake such a level of transportation risk.

With regard to purchasing refined oil products, it is more common to find CFR and CIF shipping terms being applied in the sale and purchase contracts, since the seaborne transport of those products is subject to the demand of strict oil specifications. Particular temperatures and pressure are required during the whole voyage. In addition, the required specification of petrochemical is different from country to country. The seller may need to blend different petrochemical products together during the voyage, in order to produce the right specification product for the customer. Hence, CFR and CIF, in which marine transportation is arranged by the seller, are commonly applied.

Table 1 at the next page summarizes the four shipping terms for the sale and purchase contracts with waterborne transport solely. The level of participation in seaborne transport is thus presented according to different shipping terms. From a crude oil buyer's perspective, shipping terms FAS and FOB mean that the buyer is required to arrange the transportation; thus he is more active in participating in seaborne transport than the one who applies CFR or CIF, in which the seaborne transport is arranged by the seller.

Table 1: Shipping terms in crude oil sale and purchase contracts

Incoterms 2010 (Solely by Water Transport)	FAS	FOB	CFR	CIF
Load to truck	Seller	Seller	Seller	Seller
Export- duty payment	Seller	Seller	Seller	Seller
Transport to exporter's port	Seller	Seller	Seller	Seller
Unload from truck at port of origin	Buyer	Seller	Seller	Seller
Landing charges at port of origin	Buyer	Seller	Seller	Seller
Transport to importer's port	Buyer	Buyer	Seller	Seller
Unload onto trucks from the importers' port	Buyer	Buyer	Buyer	Buyer
Transport to destination	Buyer	Buyer	Buyer	Buyer
Insurance	Buyer	Buyer	Buyer	Seller
Entry - Customs clearance	Buyer	Buyer	Buyer	Buyer
Entry - Duties and Taxes	Buyer	Buyer	Buyer	Buyer
Participation in Marine Transport (From **buyer**'s perspective)	Active →			Passive
Participation in Marine Transport (From **seller**'s perspective)	Passive ←			Active

Source: Incoterms(2010)

3.2.3 Shipping Contracts

Oil Companies form various types of shipping contracts according to different chartering strategies. Various shipping arrangements involve different levels of commitment in crude oil transport, different types of risks, and different levels of financial exposures. The following paragraphs introduce contemporary shipping arrangements for crude oil transport as another scale to define the levels of participation in seaborne transport for oil companies.

Voyage charter

A voyage charter is the most common contractual agreement for crude oil transport. Under a voyage charter, the oil company contracts with a shipowner for a specific vessel to carry a specific cargo from loading ports to discharging ports at a negotiated price per metric ton (1 metric ton (MT) = 1000 kilogram) or at a lump-sum based price. The terms and conditions are to be set out in a Charter-Party, the particular contract for a voyage charter. The shipowner is responsible for performing the voyage and pays for all the costs involved including operating and voyage costs. The charterer would mostly need to pay the freight costs when the voyage is completed.

Under this contract, shipowners are responsible for technical, operational, and commercial activities. Charterers only buy the full-package of transport service from shipowners. Hence a voyage charter is considered the contractual agreement with the most limited financial exposure and with the least sophisticated shipping arrangement for charterers.

Contract of Affreightment

A contract of affreightment ("COA") is more sophisticated than a voyage charter. The charterer nominates the minimum amount of cargoes per year to a certain shipowner who is capable of providing the transport service with his fleet. They may agree upon a fixed price for all the voyages or a floating price benchmarked from an industry index, such as Baltic International Tanker Routes.

A COA could be regarded as a time charter commitment since it often includes a binding requirement of the minimum amount of cargoes to supply per year. Shipowners under this contract are still responsible for technical, operational, and commercial activities; charterers, maintaining the same contractual obligation as under voyage charter, outsource all the shipping arrangements to shipowners by purchasing a full package of transport services, yet this time, purchasing a bundled package, for instance, 1 voyage per month for the whole year, rather than a single voyage. This arrangement is mutually beneficial. For the shipowners, the COA provides a stable income through a steady cargo supply and allows them to better utilize their fleet. For the charterers, freight discounts could often be obtained for a larger package of transport services.

Furthermore, it is more efficient in terms of commercial negotiation since all the freight costs and shipping conditions are agreed by both parties on beforehand.

Similar to the COA, the **Freight Service Agreement ("FSA")** provides a general frame transportation agreement between the oil company and the shipowner but without any minimum requirements. It could be considered a loose type of COA, a memorandum to cooperate under the condition that the charterer requires transport service and that the shipowner's fleet is available to transport the subject cargo. Many East Asian oil companies in Korea, Taiwan, and Thailand welcome this type of contract since there is no strict obligation to fulfill the minimum amount of cargoes per year, yet the freight discount could be obtained from the shipowner, who is expecting a binding COA relationship in the future.

Time Charter

As the name indicates, in a Time Charter contract charterers hire a vessel on a period basis instead of voyage basis. A time charter can vary from the time it takes to complete one voyage, in which case it can also be called a trip charter, to as long as the vessel's economical life. The most common time charter periods for crude oil transportation are 1, 3, and 5 years. When on charter, the charterer, apart from paying a daily hire to the shipowner, directs the commercial activities of the vessel and pays all voyage expenses and cargo handling costs. The shipowner continues to pay for the operational and technical activities such as repair and maintenance costs and the crew expenses.

A time charter is more sophisticated and involves more risks for both charterers and shipowners than a voyage charter and a COA. Terms and conditions of the contractual agreement are set out in the Time Charter-Party, the particular contract for Time charter. The vessel's specification and performance, from speed, bunker consumption, to cargo capacity, are all stated in the contract. The hire could be adjusted in the situation that the ship does not perform to the satisfaction of the charterer as stated in the contract. Thus the owner is required to operate the ship efficiently for the stable hire payment. For charterers, hire payment is on period basis; therefore even when there are no cargoes available for the vessel, charterers are still required to pay pre-agreed hire costs without the option to terminate the contract at his own discretion.

Owners and charterers consider a time charter contract attractive from different perspectives. For shipowners, a time charter contract paves a clear path for planning the ship's budget as the future cash flow of the ship is known and most of time agreed upon on a fixed basis. In addition, with the evidence of stable income, a time charter contract could be regarded as security for a loan to build or purchase a ship. Furthermore, shipowners have different core competences with some focused on technical management while others focusing more on asset management. In these cases, a time charter contract allows them to concentrate on their core business since commercial activities are outsourced to others. For charterers, it may not be of their interest to become shipowners, yet their business may require them to take commercial control of ships. In this case, a time charter contract may be an efficient arrangement. A time charter contract will not alter the balance sheet of the company hiring the vessel as the company is not entitled to the ownership under the contract. Hence excessive fluctuations in the price of the vessel will not distort the figures in the balance sheet and in annual financial reports. Another reason a time charter may be beneficial is that experienced charterers are able to take position in advance in the tanker market by hiring ships, as a means to speculate future market movements and hedge their risk.

Pricing in Time Charters

There are various forms of pricing in time charter contracts. Different forms of pricing entail different levels of risk sharing between the two parties involved. In spot chartering, charterers could simply fix a voyage based on the last fixture reported on the transparent spot market. Since the market rates reported are the only benchmark for spot chartering, a freight rate close to the market level could be considered reasonable. Neither charterers nor shipowners could disagree upon it. However, this is often not the case for time charter contracts. What is a reasonable rate for an oil company to pay for a time charter contract? Players in the market are not only requested to benchmark from time charter market; they are also required to benchmark from spot market so as to see whether the decision of taking a position in a time charter market is wise. To compare the spot rate and the time charter rate, the Time Charter Equivalent ("TCE") is presented hereunder as the comparison basis of spot and time charter rates as the reference for assessing a reasonable time charter rate.

To calculate the TCE, the total freight rate paid for a typical long-haul tanker voyage under a voyage charter contract is calculated as shown in equation 1 below.

Equation 1:

$$\mathrm{TFC} = \mathrm{WS}/100 \times \mathrm{FS} \times \mathrm{MinC} + \frac{1}{2}\mathrm{WS}/100 \times \mathrm{FS} \times (\mathrm{TC} - \mathrm{MinC})$$

Whereas:

TFC=Total freight costs under a voyage charter contract ($);

WS= Worldscale Freight Rate, the pricing index based on the cost of operating a standard tanker on a particular route;

FS= Tanker Nominal Freight Scale ($/MT), the standard transport cost for one unit (1 MT) of oil for a particular voyage;

MinC= Minimum Cargo Size (barrel or metric tonne); and

TC=Total Cargo Size (barrel or metric tonne)

The Time Charter Equivalent ("TCE") is then calculated using the TFC as shown in equation 2 below:

Equation 2:

$$\mathrm{TCE} = \frac{\mathrm{TFC} - (\mathrm{BC} + \mathrm{PC} + \mathrm{FT} + \mathrm{Comm})}{\mathrm{RTD}}$$

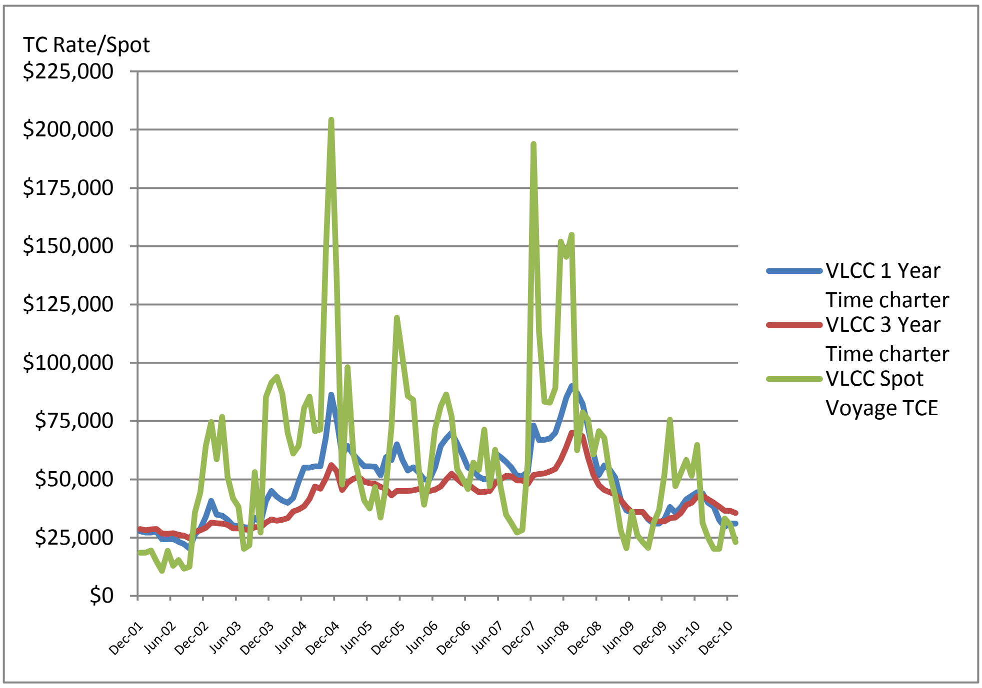
Whereas:
TCE=Time Charter Equivalent rate ($/day)
TFC= Total freight costs under a voyage charter contract ($)
BC=Bunker Costs ($)
PC=Port Costs ($)
FT=Freight Tax (if applicable) ($)
RTD=Round Trip days (days)
Comm= Commission

Once TCE ($/day) is generated from the total freight costs (TFC), it can be compared with the time charter rate ($/day). Fig. 5 at the next page is the comparison of VLCC spot voyage TCE with time charter rates from 2001 to 2010. It can be observed that spot market is far more volatile than the time charter market. It can also be seen that a 1-year time charter contract is more volatile than 3-year time contract. The longer the duration of a time charter the smoother the freight rate trend.

An oil company is therefore able to anticipate market movement by taking a position in the time charter market using the TCE as a tool to compare both markets. For instance, a VLCC charterer taking a position in chartering a 3-year period time charter vessel in June 2003 at the average price of USD29,000/day would be faced with a particularly strong VLCC spot market for the next 3 year at an average TCE of USD72,345/day thus enjoying savings of USD43,345/day for crude oil transport for 3 years. Assuming that the time charter VLCC is 350 days per year on hire, carrying 1.9 million barrels of crude per voyage and performing 9 voyages from the Middle East Gulf to the Far East per year, the time charter saving USD 43,345/day would be equivalent to $0.89 saving per barrel of crude for the whole year, a significant saving for crude oil procurement.

$$(\$43{,}345/\text{days} \times 350 \text{ days} \div 9 \text{ voyages} \div 1.9 \text{ million} = \$0.89 \text{ saving/barrel})$$

Figure 5: VLCC spot voyage TCE vs. Time Charter Rates



Source: Clarksons, compiled by Jessica Chia-Chi Wang

Time Charter Pricing Schemes

In pricing time charters there are several possible arrangements that can be considered depending on the interests of the parties involved and their level of risk. There are three types of pricing schemes which can be considered: **fixed rate/hire, profit sharing, and FFA hedging**.

Under time charter contracts, a **Fixed-rate/hire** is the least sophisticated pricing structure. Still several other pricing structures exist as a means to share the risk of uncertain market movements.

Profit-sharing is a useful solution when both parties are uncertain about the market development. The pricing structure is to combine a pre-agreed fixed daily hire rate with a floating profit sharing mechanism based on a benchmarking index. Under the structure, both parties share the freight risk resulting from the price gap between the spot and time charter markets. In the situation that a spot rate according to the index is higher than the pre-agreed hire rate; the charterer compensates a certain percentage of the price gap to the shipowner. When the spot rate, however, is lower than the pre-agreed hire rate, the charterer still needs to pay the pre-agreed hire rate to the shipowner. Under the profit-sharing pricing mechanism, the agreed fixed rate is usually lower than the hire rate under fixed-rate pricing mechanism, since the charterer needs to compensate the shipowner when the TCE in the spot market is higher than the pre-agreed time charter hire rate.

Another pricing mechanism for tanker charterers to lower the risks from uncertain freight market movement is to hedge the time charter rate by taking a position through **Freight Forward Agreements (“FFAs”)**, which are freight derivatives enabling charterers, shipowners, or any independent investors to speculate or hedge risk against physical positions in shipping market. Many freight products are developed according to different types of vessels (Tanker, Dry bulker, and Container), sizes of ships, routes, and forms of contracts (voyage or time charter). For many independent investors, the FFA is purely an instrument that could be used to speculate on the freight market. For those who have physical positions in shipping markets such as oil companies, however, the FFA could be a risk management tool to minimize losses resulting from freight cost volatility. The tool is especially welcomed by oil trading companies, who are also active in the oil paper market and commonly hedge part of their physical marine transportation position on FFAs. A good example can be found in the case of Koch Supply & Trading Company, an international oil trading company who is well-known for its flexible simultaneous action in both time-chartering in crude oil tankers and locking in at least 30% of the physical position with FFAs.

Some Chinese charterers have developed a new business model in tanker chartering, combining the concepts of time charter and shipping pool management. Shipping pools, according to the definition within EU law, are “joint ventures between shipowners to pool vessels of similar types, with central administration, which are marketed as a single entity to negotiate voyage/time charter contacts and contracts of affreightment, where the revenues are pooled and distributed to owners…”. To achieve the dual goal of satisfying own transport demand and outsourcing the care of the administration of the vessels, those Chinese charterers time charterer-in tankers and sign another contract with experienced tanker pool management companies such as Tanker International or Frontline so as to outsource the commercial activities. Based on the quantity of vessels they contribute to the pool, they are able to request the transport service of a tanker from the pool company whenever there is some transport demand. The oil company pays management fee and shares the profit or loss with the pool management company under a pre-arranged weighing system. The aim of the model is to operate the time chartered tanker efficiently, minimizing any wasting time resulting from poor scheduling or the situation of no cargoes available. This model is a relatively new phenomenon in the tanker industry.

Bare-Boat Charter

A Bare-Boat Charter allows the charterer to have full control of the ship but leaves the ownership with the shipowner. Under the contract, the charterer manages the ship and pays for nearly all costs, including voyage, cargo handling, operating, maintenance, and crew, but not the capital costs. This type of contract normally spans 10 to 20 years covering all or most of the economical life of the ship.

A bare-boat charter is considered attractive for a shipowner who is pure investor or asset manager such as a financial institution who is only interested in providing financing for the vessel and has no intention to get involved in vessel operations. For a charterer, a bare-boat charter allows the charterer to have full control over the ship without having the value of the vessel disclosed on the balance sheet. The deal grants the shipowner (the original owner of the ship) a tax benefit as well as allows the charterer (the disponent owner) to avoid having to tie up its capital to the contract. Essentially, a bareboat charter could be categorized as a financial lease agreement.

Bare-boat charter contracts were popular among oil majors during the1970s. Yet time charter contracts gradually gained more popularity among oil companies since time charter contracts also allow the charterer to commercially control the ship but are much less complicated than bare-boat charter contracts in terms of negotiations and operations.

Owned Vessel

To fully participate in marine transportation, oil companies could build their own tankers. This option, however, has become less popular considering the fact that the liabilities resulting from oil pollution accidents can be catastrophic. Various crude oil tanker spill accidents such as Exxon Valdez, Prestige, Erika over the last 2 decades have strengthened this belief.

Table 2 presents charterers' financial exposure for aforementioned shipping contracts. Among all the financial exposure items in this table, the asset title is granted to the registered owner, i.e., the shipowner who registered the ship and has the right of possession of the ship. Finance costs are also called capital costs, representing the capital of the investment. Operating expenses, also called OPEX, include all the expenses of maintaining the ship in an operating condition, such as crew wages, provisions, maintenance, repairs, lubricant oils, insurance, and overheads. Hire costs are the daily costs paid by the charterer to the shipowner for the service of the time charter vessel. Voyage costs are composed mainly of two items, bunker and port costs. The last item, freight costs, is the freight the charterer paying to the shipowner under a voyage charter.

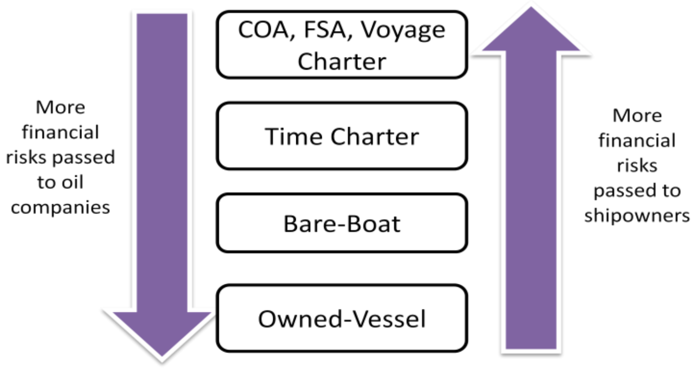
Table 2: Financial exposure of shipping contracts to Charterers

Financial Exposure	Shipping Contract					
	Owned Vessel	Bareboat Charter	Time Charter	COA	FSA	Voyage Charter
Asset Title	v					
Finance Costs	v	v				
Operating Costs	v	v				
Hire Costs			v			
Voyage Costs	v	v	v			
Freight Costs				v	v	v

Source: Mcquilling, Stopford; compiled by Chia-Chi Wang

Table 2 as above depicts the risk sharing schemes between charterer and shipowner under various types of shipping contracts while Figure 6 depicts the financial risk associated with different types of shipping contracts. Different types of contracts entail different risk sharing schemes between the charterers and the shipowners. In general financial risk distribution is the most important criteria for oil companies when considering different shipping contractual agreements.

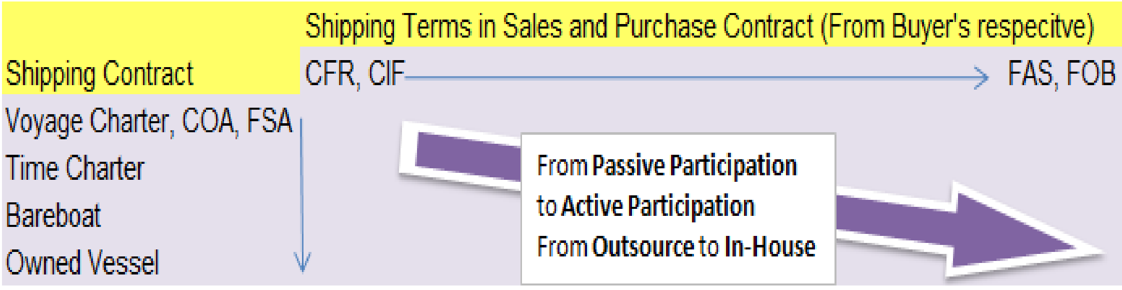
Figure 6: Financial risk distribution for different shipping contracts



3.2.4 Participation in Crude Oil Transportation and Chartering Strategies for Oil Companies

As mentioned above, different types of contracts entail different types of risk. An oil company's level of participation in crude oil transport can be assessed based on the type of shipping contract normally entered into by an oil company as well as the shipping terms used by the oil company (Fig. 7). From the perspective of shipping terms in sale and purchase contracts, an oil purchasing company could increase the level of commitment in marine transportation by applying FOB as the shipping term and arrange the shipment on its own. From the perspective of shipping contracts, an oil company can be involved in one or more of the following contracts, listed in order of increasing participation: voyage charter, COA, FSA, time charter, bareboat and owned vessel.

Figure 7: Participation Matrix

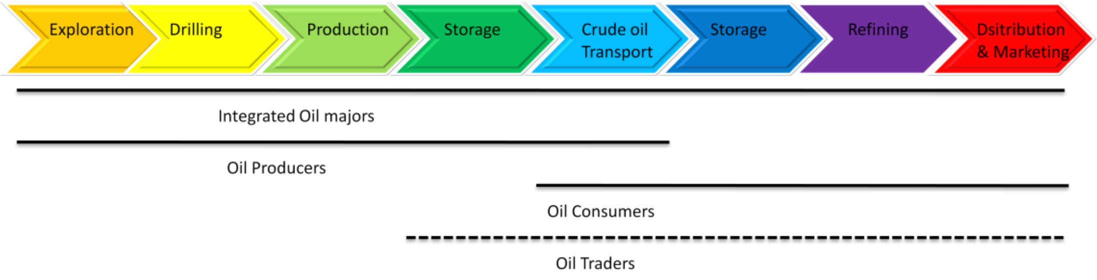


Source: Mcquilling

As the level of commitment increases, companies will consider taking commercial, operational or even technical activities in house. Manpower will be increased and the organizational infrastructure will be more complex.

Hereunder we derive the patterns of oil companies' participation in crude oil transportation and chartering strategies from categorizing them according to their main activities involved in the supply chain (Fig. 8) and then illustrate the factors influencing the patterns.

Figure 8: Categorizing oil companies based on different activities involved in the supply chain



Oil companies could be categorized into four groups: integrated oil majors, oil producers, oil consumers, and oil traders according to the main activities involved in the supply chain (Fig. 8).

Integrated oil companies

Integrated oil companies are fully vertically-integrated companies who manage the entire oil supply chain from the upstream exploration to the downstream sales and marketing. In terms of crude oil transportation, these companies are normally extremely active and building highly sophisticated logistic structures. Commercially, they commonly form a subsidiary to manage a large volume of tankers, including signing shipping contracts (mostly bare-boat and time charter contracts) and scheduling own fleet, fulfilling the in-house transportation demand. With regard to operational and technical activities, they normally train their own crew and maintain the conditions of the vessels in-house as well.

Participation in crude oil transportation: Integrated oil companies

The extremely active participation in crude oil transport is based upon the consideration that the quality of transportation is essential. Apart from active participation in all the activities of crude oil transportation, these integrated companies developed Sire System, a information shared platform to inspect the quality and the voyage history of oil tankers in order to ensure safety and quality of transportation. Tankers are required to be inspected by the vetting personnel in these companies regularly in order to have the record of

Sire Report, the required document for tankers to carry cargoes or to visit the ports of the integrated oil companies.

Shipping contracts and chartering strategies: Integrated oil companies

In recent years, these integrated oil companies have become more sophisticated in the capital allocation processes and have sought to maximize the return on invested capital. They have recognized that utilizing large amounts of the corporation's capital to purchase and own vessels may not be as efficient as investments in high return activities such as upstream exploration. Meanwhile, concern over the significant liabilities involved with regard to oil pollution, limits their appetite for managing a large fleet. In order to control the quality of transportation while minimizing the capital investment and liabilities of ownership, these integrated oil companies go for a mix of shipping contracts such as bare-boat, medium to long-term time charter, and COA together with voyage charter contracts.
Period-based contracts are used in order to meet a certain degree of their long-term transportation requirement, whereas spot contracts are used for their extra transportation needs, which might be trading, cyclical, or seasonal cargoes.

The aim of this type of chartering strategy is to control transportation quality. Two methods are generally applied by the integrated oil companies to achieve this goal: at least 20%~40% of period-based fleet chartered from carefully selected shipowners and a strict tanker vetting system.

Companies such as ExxonMobil, Chevron, Shell, Total, and BP fall within this category.

Oil Producers

Oil producers' main activity is to produce and sell crude oil. Although many of them stretch their business to downstream activities such as refining and marketing petrochemical products, their core business remains crude oil production and export. Therefore, all the other processes in the supply chain are serving and facilitating the core business, including crude oil transportation.

Participation in Crude Oil Transportation: Oil Producers

The participation in crude oil transportation for oil producers is varied. However most of the oil producers with large-volume crude oil sale and purchase contracts, notably the companies based in Middle East Gulf region, are governmental companies with the support of ample national capital therefore have the ability to participate heavily in shipping. Some companies control and manage their own loading ports and tanker terminals; others co-manage their ports with integrated oil majors through subsidiaries under joint-ventured schemes. Likewise, in terms of participation in crude oil transportation, they also form subsidiaries to acquire and manage the fleet, for the purpose of temporary storage or fulfilling the sale and purchase contracts with CIF or CFR shipping terms. Hence big oil producers normally actively participating in crude oil transportation.

Shipping contracts and chartering strategies: Oil Producers

Oil producers are less sophisticated in the capital allocation processes than integrated oil majors due to the fact that they often have ample capital from their oil business and enjoy strong government backing due to the strategically important nature of the oil sector. Oil producers therefore have a solid ground to diversify their investment into crude oil tanker business. Most of big oil producers in Middle East Gulf region own their own domestically flagged fleets. Some are also interested in other forms of shipping contracts, such as time charter contracts, COA, and voyage charter contracts from time to time depending on market conditions.

Like the integrated oil majors, the big oil producers similarly have long-term chartering strategies. They renew their fleet continuously and manage the fleet in-house in order to facilitate the crude oil business. Faced with increased environmental concerns, they adopted the tanker vetting system introduced by integrated oil majors and actively improve the quality of transportation.

Companies such as Vela International Limited (Saudi Arabia), Kuwait Oil Tanker Company (Kuwait), Qatar Shipping (Qatar), and the National Iran Tanker Company (Iran) fall within this category.

Oil Consumers

Oil consumers are defined as the regional- or country-based oil companies whose main business is to refine the imported crude oil and distribute the petrochemical products to their end consumers. Their core activities in the supply chain are downstream refining and marketing. Since the costs of refining oil is nearly unchangeable, in order to achieve a higher margin, most companies strive for lower material costs, including the freight costs from crude oil transportation. For this type of companies, their participation in the crude oil transport business is usually cost driven.

Participation in crude oil transportation: Oil Consumers

Compared with integrated oil majors and oil producers, oil consumers' participation in crude oil transportation is low. Sophisticated logistics solutions or extensive investment in shipping are not necessary since their business is relatively small.

Shipping contracts and chartering strategies: Oil Consumers

Voyage charter contracts and FSA are commonly used for oil consumers. Some may directly own a certain percentage of their fleet in order to gain flexibility and bargaining power when chartering-in vessels. There are some exceptional oil consumers who are very active in crude oil transport or form long-term partnerships with certain ship owners for various historical, operational, strategic, or political reasons. Voyage-based contracts, however, are the most common.

Oil Traders

As indicated by the dotted line for oil traders in Fig. 8 (p 26), oil traders may or may not participate in any physical movement in the supply chain since the core business is to trade oil which can be done purely on paper. International trading companies deeply involved in crude oil trading may, however, retain a certain level of physical cargoes. Therefore, crude oil transportation is no doubt within their business domain.

Participation in crude oil transportation: Oil Traders

Crude Oil traders' participation in crude oil transportation is generally low in comparison to integrated oil companies and oil producers. Although many oil traders in petrochemical product markets are actively involved in the oil transportation business, crude oil traders are less active in the participation of crude oil transport business. The main reason for this is that oil traders are more flexibility-driven. The transparent and liquid crude oil tanker spot market happens to offer the oil traders flexible and simple transport solutions. For instance, it is often observed that oil traders require a longer range of lifting dates and several options of loading and discharging areas including the option of ship-to-ship transshipment operations in voyage charter contracts. It is also often observed that the freight rate negotiated by oil traders is higher than that negotiated by regular oil companies for the same route since oil traders seek a higher level of flexibility to facilitate their oil trading business.

Shipping contracts and chartering strategies: Oil Traders

Extensive voyage charter contracts combined with time charter contracts are the general contract patterns for crude oil traders. In addition, oil traders are more likely to embrace Forward Freight Agreements to speculate or hedge the volatility of freight rates than the above-mentioned three categories of oil companies.

International oil trading companies such as Koch Supply and Trading, Vitol, ST Shipping, and Trafigura fall within this category.

Summary

Table 3 and Table 4 summarize the patterns of shipping contracts and chartering strategies, respectively, for the four categories of oil companies discussed above.

Table 3: The patterns of shipping contracts for oil companies

Catogories of oil companies	Shipping Contracts					
	Owned Vessel	Bareboat Charter	Time Charter	COA	FSA	Voyage Charter
Integrated oil majors	v	v	v	v	v	v
Oil producers	v		v	v		v
Oil consumers	v	v	v	v	v	v
Oil traders			v			v

Table 4: The patterns of chartering strategies for oil companies

Catogories of oil companies	Patterns of Chartering Strategies			
	Participation in crude oil transportation	The aim for participation	Long-term chartering strategeis	Common shipping contrats
Integrated oil majors	**Active**	**Quality-driven**	**Yes**	**Bare-boat/TC/COA/Voyage Charter**
Oil producers	**Active**	**Serving oil business**	**Yes**	**Owned-Vessel/TC/Voyage Charter**
Oil consumers	**Medium/Passive**	**Cost-driven**	**-**	**TC/COA/Voyage Charter**
Oil traders	**Passive**	**Flexibility-driven**	**-**	**TC/Voyage Charter/(FFAs)**

3.3 Factors influencing the chartering strategies for oil companies

This section identifies the crucial factors influencing the chartering strategies for oil companies from own experiences, observations, and in-depth interviews with business experts.

Internal Factors

The main internal factor influencing oil companies' chartering strategies is the core business operated by the oil company in the supply chain analyzed in section 3.2. It can be observed that the four categories of oil companies adapt different chartering strategies according to different types of core businesses. Integrated oil companies commonly form long-term chartering strategies and represent a balanced shipping contract mix between period- and voyage-based contracts to strive for stable quality with regard to marine transportation. For oil producers, upstream crude oil production is their main business and in serving customers who demand transport services, they also tend to form long-term chartering strategies and control a large percentage of their fleets. Oil consumers with the downstream refining and marketing as the core businesses, do not form long-term chartering strategies and mainly go for voyage charter contracts, though in this group many exceptional cases can be found. Lastly, oil traders are earning profit through trading business which may or may not require physical cargo lifting. In general there are no long-term chartering strategies observed. In terms of contract mix, flexibility drives the selection of contracts thus voyage-based contracts are common.

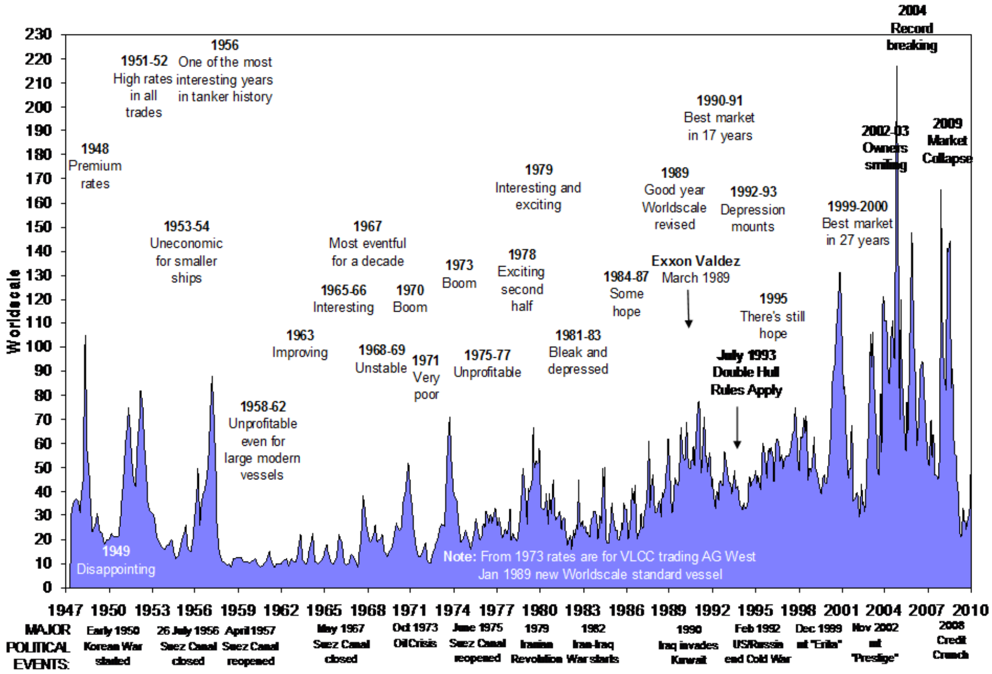
Other main internal factors are management style and risk preference. For instance, although oil companies categorized in the same group have similar core business, it can be found that some are actively involved in oil transport while others take a more passive approach owing to different management style and risk preference. For instance, S-Oil and SK, both of which are South Korean based regional consumers, represent totally different patterns of chartering strategies. The former rely heavily on short-term voyage-based contracts while the latter prefer a mix of long-term and short-term contracts.

External Factors

The main external factors influencing the chartering strategies for oil companies are the market cycle and business constraints. The tanker market cycle forces the oil companies to adjust their long-term chartering strategies. Fig. 9 presents the cyclical nature of the tanker market. In a market cycle in which increasingly strong spot freight rates are foreseen, even traditionally spot-market based charterers welcome long-term shipping contracts so as to hedge against increasing spot rates. On the other hand, a continuously low spot market gives the traditionally period-market based charterers the incentive to get rid of period contracts. For instance, Vela

International Limited, notable for owning a significant portion of its own fleet to serve the transport demand of the Saudi Arabia Oil Company, deferred his tanker newbuilding plan in 2010 since the low spot tanker market rate did not justify investment in additional tanker tonnage. They instead chartered in short-term time charter vessels and increased their involvement in the spot market temporarily, as short-term adjustment to the tanker market cycle.

Figure 9: Tanker market cycle 1947 to 2010



Source: E A Gibson, Stopford, Clarksons, SSY, Jacobs & Partners

The other crucial external factors are the various operational and environmental constraints. With regard to operational constraints, some oil companies faced with particular logistic conditions are forced to adopt certain types of chartering strategies. For instance, Sun Oil, a North America-based oil refinery faced with the draft restriction of Delaware River, the necessary pathway to its refinery, develops long-term business relationship with shipowners with shallow-draft tankers. The draft restriction facilitates Sun Oil's development of long-term strategic partner relationship.

With regard to environmental constraints, oil companies could be those who set up new practices to regulate the business or those whose chartering patterns are influenced by new regulations. For instance, integrated oil majors continuously developed new rules for tankers to call at their ports. For example, one integrated oil company in 2011 announced that a tanker with a captain with less than two years experience on board the particular vessel is not welcome to call at its ports. The new practice not only influenced the crew management decisions of shipowners, but also heavily influenced oil companies' chartering strategies. Companies who regularly lift cargoes from the terminals managed by the company may consider securing tonnage on a period-based contract to fulfill the transport requirement.

Table 5 summarizes both the internal and external factors influencing oil companies' chartering strategies. The list is not exhaustive. The factors listed, however, are considered crucial and often have been cited as having a major influence on chartering strategies.

Table 5: Factors influencing oil companies' chartering strategies

Factors influencing oil companies' chartering strategies	
Internal Factors	Core Business
	Management Style
	Risk Preference
External Factors	Market Cycle
	Business Constraints (Operational, Environmental…)

3.4 Conclusion of chapter 3

This chapter highlights the criticality of crude oil transportation in the oil supply chain by presenting the nature of its multiple functions. In order to analyze the patterns of participation in crude oil transportation and chartering strategies, we categorize oil companies according to their core business from the perspective of supply chain and later on discuss the crucial factors influencing oil companies' chartering strategies.

4. Theory and Methodology for Shipping Contract Mix Problem

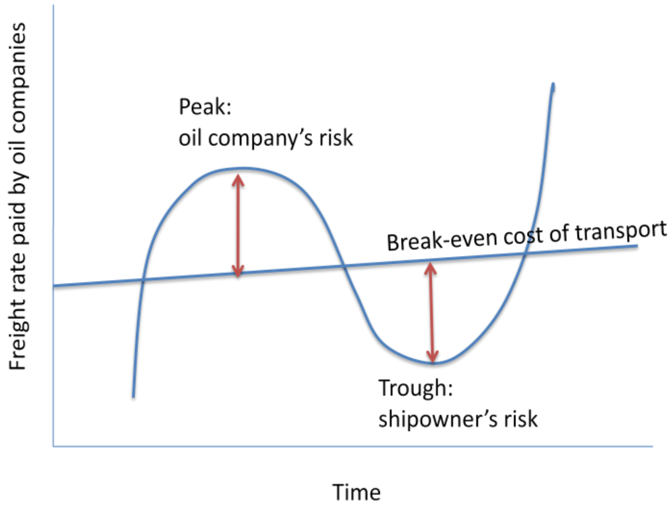
A topic which is always discussed in chartering strategies for oil companies is the shipping contract mix problem, namely, the trade-off between period-based and voyage-based shipping contracts. Typically oil companies strive for a long-term chartering strategy which serves the companies' strategic goals while matching the companies' risk preferences. While most oil companies are still approaching the contract mix problem intuitively, in this chapter we aim to provide an in-depth quantitative analysis based on Modern Portfolio Theory in order to approach the problem scientifically.

4.1 Contract Mix Literature Review

There are limited literatures available regarding trends in shipping contract portfolios among oil companies. One of the few sources of information on this topic, Stopford (2010), argues that the strategic choices of oil companies to distribute the shipping risks between the spot and period market is a matter of internal company policy and that the balance may change in accordance with external circumstances.

Since the 1970s there has been a shift in shipping contracting from period based contracts to voyage based contracts. This shift is the result of various historical events and developments in the oil industry since the 1970s. Experiencing the oil crises of the 1970s, both the oil and tanker markets became more volatile and unpredictable. Moreover, an oil trading market has been developed which led to many oil traders joining the business. These oil traders required flexible tonnage thereby creating demand for voyage based contracts. Furthermore, "charter-backed finance" between ship owners and oil companies gradually shrank in importance during 1970s and 1980s due to the fact that many independent owners not only had the ability to completely finance their own ship investments but also started to embrace the opportunity to gain extra profit from the volatile spot market.

Figure 10: Freight risk features of the shipping cycle



Source: Stopford(2010)

Figure 10 depicts the freight risk pattern of the shipping cycle. The picture also expresses the value added by having a contract mix as it smoothes the volatile expenses/revenues spent/earned due to the cyclical pattern of shipping market. When the spot market is at its peak, an oil company needs to pay freight higher than the break-even transport cost. The situation is unfavorable to the oil company thus an oil company may have planned to lock-in period-based contracts to avoid the extra costs during the peak of the shipping cycle. Likewise, a trough in the shipping cycle is unfavorable to a shipowner since he is required to subsidize his counterparty by offering transport services with cost lower than the break-even point. It is thus generally agreed that a period-based shipping contract, most commonly a time charter contract, provides the oil companies stable transport service in terms of quantity, quality, and cost of the service; while a voyage-based contract grants the flexibility to cope with uncertain demand

.

Besides Stopford, there are a few other sources of literature addressing the issue of contract mix problem for various industries.

Most of these papers seek to reconcile the dual goals by balancing the long and short-term contracts. The following two procurement literature studies in electrical utilities and DRAM industries are summarized which may shed light on our study.

Electrical Utilities Industry

Bonser and Wu (2001) studied the practice in fuel procurement for electrical utilities: a fuel buyer purchases the fuel on a long-term contract with a fixed price and fulfils extra demand from short-term contracts at current market price. Procurement decisions are made in two phases. In the first, minimum contract purchases for the entire year are determined at the beginning of the year. In the second, more detailed planning covering the potential purchases is decided on a monthly basis. The authors assumed that spot fuel prices are usually lower than contract prices and provide the flexibility buyers are looking for, but are more risky due to potential price spikes or limited supply from the spot market. Based on the assumption, the authors provided a procurement strategy satisfying the pre-committed long-term contract quantity while offering flexibility to benefit from monthly updated demand forecasts and to exploit short-term market fluctuations. The assumption made for the solution is however disputable in theory and may not be applicable to shipping contract mix problem. Theoretically speaking, the price of the long-term contract should equal the *expected spot price* for the equilibrium of both markets (Spinler and Huchzermeier, 2006).In reality, whether the spot prices are higher or lower than the long-term contract prices really depends on the market circumstance over the time-frame; in some situation the spot prices are lower than long-term contract prices while in others vice versa. It is probably too brave to assume a “usual” case in shipping market nowadays since the freight pattern itself again and again overturns most of the usual predictions in the past. In the shipping market, a rational shipowner is willing to secure a long-term shipping contract with a discounted price in the belief that the firming spot market will end soon. On the other hand, when the shipping market is severely oversupplied and spot prices are low, in some cases even lower than OPEX, a rational ship owner may expect higher spot price in the future and is thus unwilling to secure his tonnage on a long-term basis at a discounted price. He may, instead, ask for higher prices for period-based contracts. Owing to the disputable assumption, the recommended procurement strategy generated in the paper may not be applicable to chartering strategies for oil companies.

Dynamic Random-Access Memory (DRAM) Industry

Different from the assumption made by Bonser and Wu (2001), Serel et al. (2001) assumed that the spot market involves an anticipated price premium compared with the price of long-term forward contracts. The long-term forward contract is given a lead time with an agreed fixed price; while for spot purchasing, there is no lead time and the price is stochastic. Given these assumptions, the authors reached the conclusion that the buyer's reliance on forward contracts decreases with the increasing degree of risk aversion even though spot market entails a price premium in the long run. The authors applied the results to the component procurement decisions of DRAM industry. The result could also apply to chartering decisions for oil companies. Most state-owned oil companies, different from trading companies taking risk for potential profit from volatility of freight markets, are making chartering decisions from a rather conservative perspective. Instead of gambling on potential savings from future freight expenses by concluding long-term contracts in advance, they would rather rely on the spot market. The conclusion of this study is therefore in line with the empirical evidence explained in the chartering strategies for oil companies.

4.2 Theory and Methodology

The objective of this section is to describe the methodology that will be used for analyzing the contract mix problem as well as explain the theory behind the methodology.

4.2.1 Coverage Ratio

The coverage ratio is a strategic planning benchmark for oil companies with regard to chartering strategies. The ratio is the controlled fleet of the company divided by the total marine transportation requirements. The controlled fleet could be any type of long-term contract such as owned vessels, bare-boat, or time charter in opposition to voyage charter contracts. It can be expressed as equation 3:

Equation 3:

$$\text{Coverage Ratio} = \frac{\text{Demand fulfilled by Controlled Fleet}}{\text{Total marine transport demand}}$$

Demand in the coverage ratio calculation is generally expressed in the form of equivalent shipment, namely, the number of voyages. For instance, a coverage ratio 60% means that the company satisfies 60% of the total transport demand with its controlled fleet. If the total marine transport demand for the company is 100 Suezmax tanker voyages in the West Africa to United States route per year, the company needs to perform 60 voyages per year with the controlled fleet. Assume one Suezmax tanker could handle 8 voyages for the particular route annually; the company thus needs 7.5 time charter vessels assuming that the company has no other types of long-term shipping contracts.

Integrated oil companies generally have a coverage strategy while other categories of oil companies differ in the benchmark. ExxonMobile claimed that its long-term coverage strategy is one-third cargoes transported by controlled fleet, one-third by COA, and one-third by spot market tankers. Other integrated oil companies such as Chevron, Shell, Total, and BP had not revealed the coverage strategy; yet it could be observed that in general they aim to cover at least 20~40% of their crude oil transport demand with the controlled fleet.

4.2.2 Portfolio Theory

The traditional belief that it is not wise to put “all eggs in one basket” describes the fundamental concept of spreading risk through diversification of investment targets. Harry Markowitz‘s Modern Portfolio Theory (“MPT”) proved this conventional wisdom precisely correct and won him the Nobel Prize in 1990. The premise of the theory is that diversification reduces variability. While the return of a portfolio is equal to the weighted average of the rate of return on its individual holdings, the risk, the volatility of the return, could be less than the weighted average of the risk on its individual holdings (Ansari 2006). Hence diversification could be regarded as a free lunch in which an investor could select a portfolio of high return investment targets while maintaining the volatility of the return of the portfolio less than that of average volatility of each holding as long as the returns of each of the holdings are not perfectly correlated. The diversification mechanism of portfolio theory is described mathematically as follows.

Portfolio return (n=2):
Formula 1:

$$E(r_p) = x_a E(r_a) + x_b E(r_b)$$

Where $E(r_p)$ is the expected value of a portfolio return including securities a and b. $E(r_a)$ and $E(r_b)$ are the expected returns of securities A and B, respectively. x_a and x_b are the fractions of capital investment in security a and b. The summation of x_a and x_b should be 1, as described in Formula 2.

Formula 2:

$$x_a + x_b = 1$$

Formula 3:

$$\sigma_p{}^2 = (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_a x_b COV_{a,b}$$

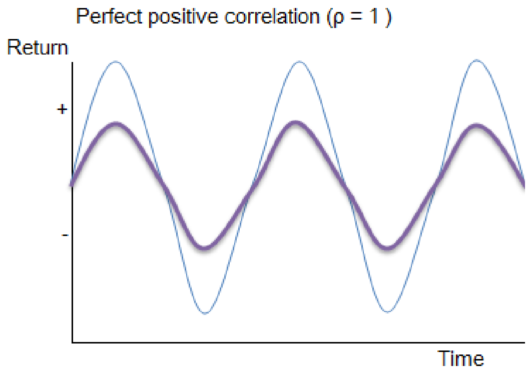
In formula 3, $\sigma_p{}^2$ is the variance of the portfolio while σ_a and σ_b are the standard deviation of return for a and b, respectively. $COV_{a,b}$ is the covariance of a and b. The relationship between covariance ($COV_{a,b}$) and the Coefficient of Correlation ($\rho_{a,b}$) is as shown in Formula 4.

Formula 4:

$$COV_{a,b} = \rho_{a,b}\sigma_a\sigma_b$$

If $\rho_{a,b}$ equals 1(Fig. 11), securities a and b are perfectly positively correlated and there is therefore no risk mitigation effect. The standard deviation of the portfolio equals the weighted average of standard deviation of a and b, described as follows.

Figure 11: Perfect positive correlation ($\rho_{a,b} = 1$)

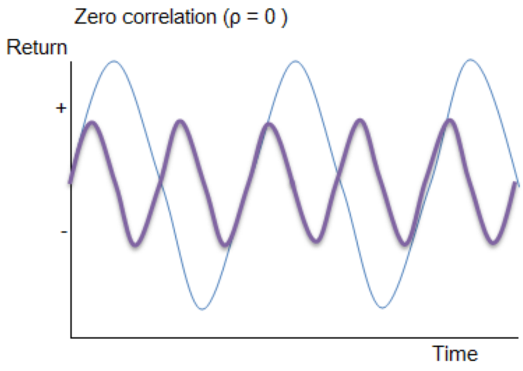


If $\rho_{a,b} = 1$,

$$\begin{aligned}\sigma_p{}^2 &= (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b\boldsymbol{\rho_{a,b}}\sigma_a\sigma_b \\ &= (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b\mathbf{1}\sigma_a\sigma_b \\ &= (x_a\sigma_a + x_b\sigma_b)^2 \\ \sigma_p &= x_a\sigma_a + x_b\sigma_b\end{aligned}$$

If the Coefficient of Correlation ($\rho_{a,b}$) is, however, less than 1, there will be risk reduction effect, described mathematically as follows:

Figure 12: Zero Correlation$(\rho_{a,b} = 0)$

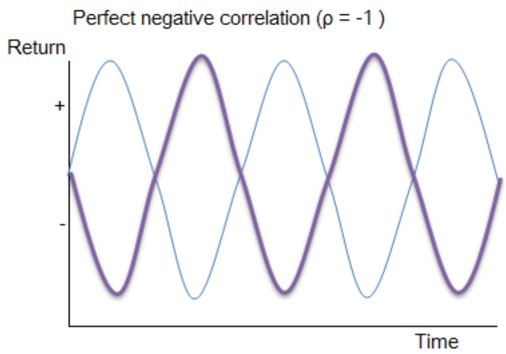


If $\rho_{a,b} = 0$,

$$\sigma_p{}^2 = (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b\boldsymbol{\rho_{a,b}}\sigma_a\sigma_b$$
$$= (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b\mathbf{0}\sigma_a\sigma_b$$
$$= (x_a\sigma_a)^2 + (x_b\sigma_b)^2$$
$$\sigma_p = \sqrt{(x_a\sigma_a)^2 + (x_b\sigma_b)^2} < x_a\sigma_a + x_b\sigma_b$$

When the Coefficient of Correlation $(\rho_{a,b})$ equals 0, it means that there is no linear relationship between a and b. It can be observed that the portfolio risk will be less than the weighted average risk of a and b.

Figure 13: Perfect negative correlation $(\rho_{a,b} = -1)$



If $\rho_{a,b} = -1$

$$\sigma_p{}^2 = (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b\boldsymbol{\rho_{a,b}}\sigma_a\sigma_b$$
$$= (x_a\sigma_a)^2 + (x_b\sigma_b)^2 + 2x_ax_b - \mathbf{1}\sigma_a\sigma_b$$
$$= (x_a\sigma_a - x_b\sigma_b)^2$$
$$\sigma_p = x_a\sigma_a - x_b\sigma_b < x_a\sigma_a + x_b\sigma_b$$

If the Coefficient of Correlation ($\rho_{a,b}$) equals -1, there will be a complete risk reduction effect. In theory, one could find a fraction composition of a and b which makes the portfolio variance equal to 0. Therefore, the investor could enjoy the positive return while having no risk involved. In reality a portfolio where all the investment targets are negatively correlated rarely exists. As long as the Coefficient of Correlation is less than 1, however, there will be some degree of risk reduction effect, summarized as Table 6.

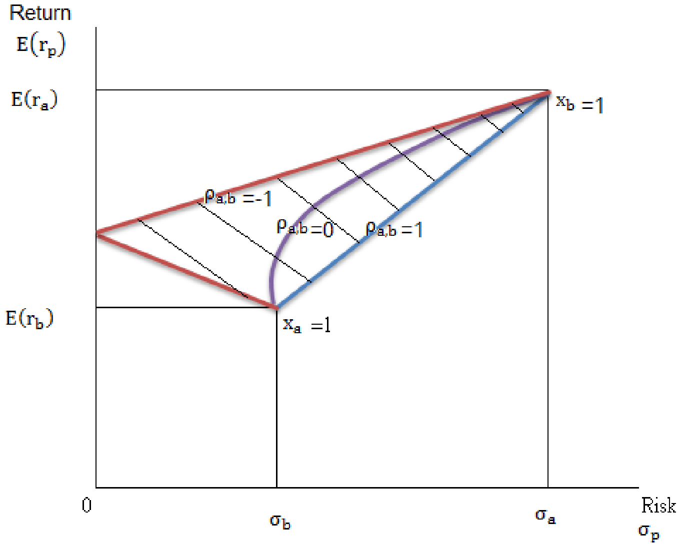
Table 6: Summary of risk reduction effect

Coefficient of Correlation	Level of risk reduction
$\rho(r_A, r_B) = 1$	No risk reduction
$\rho(r_A, r_B) = -1$	Complete risk reduction
$-1 < \rho(r_A, r_B) < 1$	Risk reduction

Figure 14 as follows depicts **the efficient frontiers** or **the efficient sets** of the possible investment combinations between securities a and b when the Coefficient of Correlation is equal to 1, 0, or -1. Those curves/lines indicate the possible combinations that maximize returns while minimizing risk or minimizing risk while maximizing return. An investor could achieve any point on those curves/lines by selecting an appropriate mix between the two investing targets according to his risk preference. One person with less tolerance for risk might choose more security A than security B; while another person with more tolerance for risk might select more security B and less security A. In the extreme end of the spectrum, a person with minimum risk tolerance may fully invest in security A for a minimum variance portfolio. No matter which case it may be, a person cannot achieve any point above the efficient set curve/line. These curves/lines are the best investing combinations already. As long as the person selects the portfolio on the efficient frontier, he has the best (the optimal) portfolio given his tolerance for risk.

When the Coefficient of Correlation is equal to 1, the efficient frontier is presented as a straight line since there is no risk reduction effect. When the Coefficient of Correlation is between -1 and 1, the efficient frontier is moving within the backward slash area in Fig. 14, representing a certain level of risk reduction effect. When the Coefficient of Correlation is -1, there will be an optimal combination that makes the portfolio risk 0.

Figure 14: Efficient frontier



4.2.3 Optimal Portfolio Modeling

The measure used to decide the optimal contract mix is a non-linear version of the cost benefit trade-off problems. In this case, the cost involved is the risk associated with the contract mix. The benefit is the expected return from the contract portfolio. The mathematical formulation to create the optimal reward and risk profile for the shipping contract mix can be presented by a deterministic mean variance model. In the model, the optimization of the contract allocation could be viewed from two different perspectives, either to maximize return subject to a given variance or to minimize variance subject to a given return. The problem could be formulated as a non-linear program with the two perspectives as follows.

Perspective 1: Maximize portfolio return subject to a given portfolio variance

Goal: Maximize portfolio return

$$\sum_{i=1}^{n} x_i r_i \qquad (1)$$

Subject to:

$$\sum_{i=1}^{n} {x_i}^2 {\sigma_i}^2 + \sum_{j=1}^{n} \sum_{\substack{k=1 \\ j \neq k}}^{n} x_j x_k \sigma_{jk} \leq \dot{\sigma}^2, \qquad (2)$$

for i, j, k = 1,…, n

$$\sum_{i=1}^{n} x_i = 1 , \qquad (3)$$

for i= 1,…, n

$$x_i \geq 0 \qquad (4)$$

Whereas:

r_i = the return of each shipping contract

$\dot{\sigma}^2$ = the risk tolerance

x_i = the weight of each shipping contract

Perspective 2: Minimize portfolio variance subject to a given portfolio return

Goal: Minimize portfolio variance

$$\sum_{i=1}^{n} {x_i}^2 {\sigma_i}^2 + \sum_{j=1}^{n} \sum_{\substack{k=1 \\ j \neq k}}^{n} x_j x_k \sigma_{jk} \qquad (1)$$

Subject to:

$$\sum_{i=1}^{n} x_i r_i \geq \dot{r} , \qquad (2)$$

for i = 1,…, n

$$\sum_{i=1}^{n} x_i = 1 , \qquad (3)$$

for i= 1,…, n

$$x_i \geq 0 \qquad (4)$$

Whereas:

$\dot{r}$ = the required portfolio return

x_i = the weight of each shipping contract

4.3 Conclusion of Chapter 4

In this chapter we provide the concept of coverage ratio, modern portfolio theory, and the optimal portfolio modeling for the preparation of contract mix analysis in chapter 5.

5. Shipping Contract Mix Problem: Case Study

Based on the methodology introduced in chapter 4, we could obtain the reward and risk profile of an existing shipping contract mix, determine the efficient frontier of the shipping contract mix subject to the given risk tolerance level, and finally compare and analyze different contract mixes and risk preference levels with a "utility" approach. In this section we present the process of analysis supported by a simplified case study from an Asian based oil company.

5.1 Sample Data for Shipping Contract Portfolio

In order to simplify the analysis we consider a contract mix of time charter and voyage charter contracts, as the mix of long- and short-term contracts.

In our analysis we focus only on long-haul crude oil transportation. Hence only VLCC and Suezmax tankers are studied which are carrying crude oil for inter-continental routes, shown in Table 7.

Table 7: Tankers carrying crude oil

Class of tanker	Ship Size (dwt)	Crude oil	Long-Haul Transport
VLCC & ULCC	200,000 ~	60%	Yes
Suezmax	120,000~200,000	30%	Yes
Aframax	70,000~120,000	10%	Rare
Panamax	50,000~70,000	0%	No
Handysize (MR)	20,000~50,000	0%	No

In terms of routes, there are various routes for global crude oil transportation (Fig. 15). The major routes for VLCC are Middle East Gulf to US Gulf, to West Europe, and to Far East as well as West Africa to US Gulf and to Far East. The major routes for Suezmax are Middle East Gulf to Far East, and West Africa to US Gulf and to West Europe. There are many other possible routes, whereas in general the routes with the largest transportation volumes are the aforementioned 5 routes for VLCC and 3 routes for Suezmax tankers.

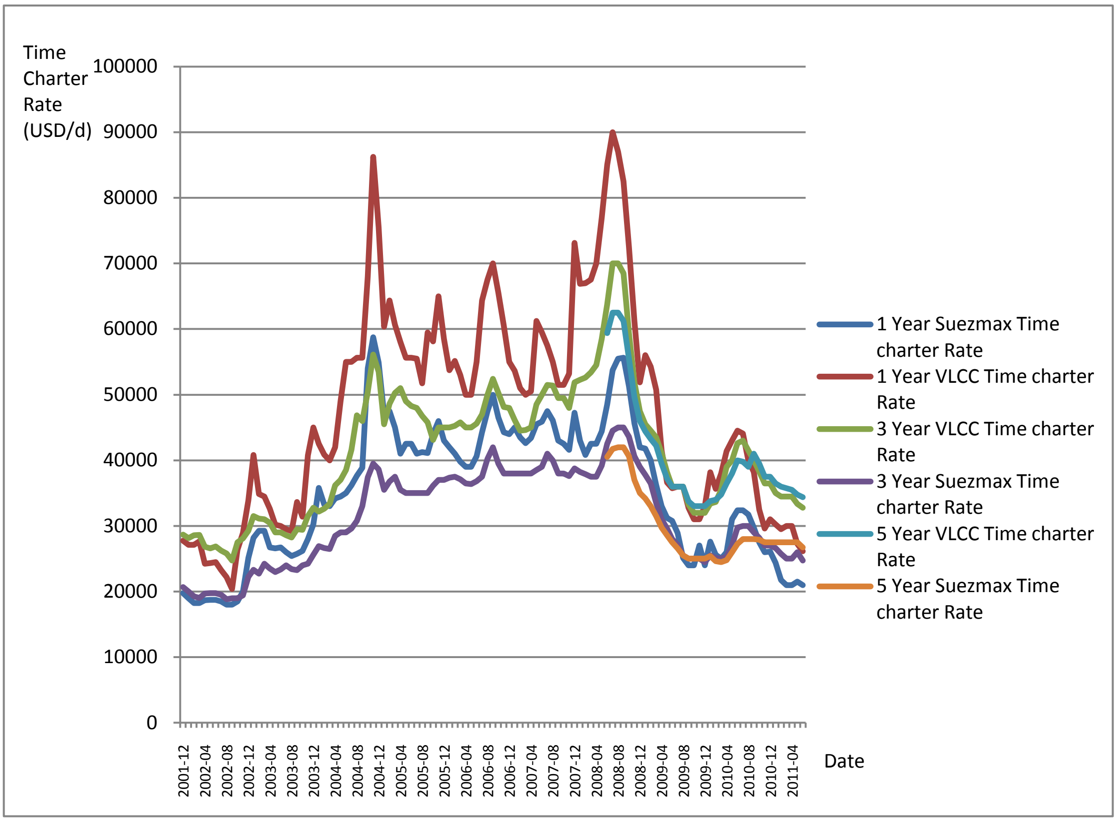
Figure 15: Global routes of crude oil transportation

In terms of time charter contracts, the most common duration which is reported on the market are 1, 3, and 5 year contracts. Hence, combining the ship size and time charter contract duration, we have 6 types of time charter contracts, shown in Table 8. The time charter rate developments for these contracts are shown in Fig. 16. Oil companies could select any of the 6 contracts as their long-term shipping contracts fulfilling part of the crude oil transport demand of specific routes.

Table 8: 6 Types of long-haul crude oil time charter contracts

List of Contract Types	Ship Type	Duration
1	VLCC & ULCC (200,000 dwt~)	1 Year TC
2	VLCC & ULCC (200,000 dwt~)	3 Year TC
3	VLCC & ULCC (200,000 dwt~)	5 Year TC
4	Suezmax (120,000~200,000 dwt)	1 Year TC
5	Suezmax (120,000~200,000 dwt)	3 Year TC
6	Suezmax (120,000~200,000 dwt)	5 Year TC

Figure 16: Time charter rates (Dec. 2001~Dec. 2010)



Note: The 5-year VLCC and Suezmax time charter rates are only applicable from June 2008.

5.2 The Reward and Risk Profile of an Existing Shipping Contract Mix

In this section we present a simplified case study from the chartering strategy of an Asian oil company (Company A) categorized in "oil consumers", showing how to generate the reward and risk of a shipping contract portfolio composed of time-charter and voyage charter contracts.

Description of Company A' s Chartering Strategy

Company A has a crude oil transport demand of 64 VLCC voyages from the Middle East Gulf ("MEG") and 32 VLCC voyages from West Africa ("WAF") to its Far East ("FE") refineries each year. The company's chartering strategy is to cover 50% of its MEG to FE voyages demand with 3 year time charter tankers, and to cover 25%

of its WAF to FE voyages demand with 1 year time charter tankers, described as Table 9.

Table 9: Company A's transport demand and chartering strategy

Routes	Yearly Demand (voyage)	Coverage Ratio	Contract Mix
VLCC MEG/FE	64	50%	3 Year TC + Spot Market
VLCC WAF/FE	32	25%	1 Year TC +Spot Market

Reward and Risk Profile of Company A' s Shipping Contract Mix

Step 1: Decide the Percentage of Time Chartered Vessels

Using the information given in Table 9, we calculate the number of time chartered vessels required based on the concept of coverage ratio and obtain the weight of the two types of time charter contracts, presented as Table 10.

Table 10: Calculation of percentage of numbers of time charter vessels

Routes	Yearly Demand (voyage)	Coverage Ratio	Voyages performed by TC/year	Voyage for 1 VLCC/year	Number of TC required	Weight of Number of TC (%)
	(A)	(B)	(C=A*B)	(D)	(E=C/D)	(F)
VLCC MEG/FE	64	50%	32	8	4	**71%**
VLCC WAF/FE	32	25%	8	5	1.6	**29%**
				Total	5.6	100%

Given the coverage ratio shown in Table 9, 32 MEG/FE and 8 WAF/FE voyages performed using time chartered vessels (64*50%; 32*25%) are required. Assuming that 1 VLCC performs 8 voyages per year for MEG/FE route (350 on-hire days/44 days required for 1 round-trip voyage) and 5 voyages per year for WAF/FE route (350 on-hire days/70 days required for 1 round-trip voyage), we obtain the number of time charter vessels required for both routes by dividing the voyages required to be performed with time charter vessels (Column C in Table 10) by the number of voyages that 1 VLCC can perform per year (Column D in Table 10). In total 5.6 VLCCs are calculated to be time chartered in for MEG/FE route (4 VLCC) and for WAF/FE route (1.6 VLCC). In reality of course, it is not possible have 1.6 time charter contracts but for the purposes of calculation the numbers were not rounded off. The weight of the two “investment targets” is 71% versus 29% as shown in Column F in Table 10.

Step 2: Calculate the Risk and Return Profile of a 3-Year TC on MEG/FE Route and 1-Year TC on WAF/FE Route

Return and Risk Formulas

From an oil company’s perspective, freight or hire is the cost item that has to be paid to the shipowners in exchange for the shipping services rendered. Calculating the risk and return on a contract portfolio is different from calculating risk and return for a portfolio of stock market investment because the oil company is striving for larger savings when it “invests” in a long-term shipping contract for fulfilling the foreseeable transport demand. These “savings” could be obtained by deducting the spot market price of a voyage charter contract from the hire cost pre-determined in the long-term shipping contract for the chartered period. Hence we could regard the “savings” after engaging in a time-charter contract as the “return” of the contract. The return can be obtained by comparing the contract shipping rate constantly with the spot market rates in the charter period. The risk of the contract is calculated as the standard deviation of the return of the contract. They are expressed mathematically as formula 5, 6, and 7.

Formula 5: Return for a time-charter contract per day (from an oil company’s perspective):

$$r_i = \frac{TCE_i - TC\_Rate}{TC\_Rate}$$

Whereas:

r_i = the return (savings) per day for a time-charter contract signed with a shipowner.

TCE_i = spot market Time Charter Equivalent per day ($/d) (Formula as equation 2 in chapter 3).
TC_Rate = Fixed rate decided in the time charter contract ($/d)

Formula 6: The expected return for a time charter contract for the period chartered (from an oil company's perspective)

$$\bar{r} = \frac{\sum_{i=1}^{N} r_i}{N}$$

Whereas:
$\bar{r}$ = the expected return for a time charter contract

Formula 7: The risk of a time charter contract for the period chartered (from an oil company's perspective)

$$\tilde{\sigma} = \sqrt{\frac{\sum_{i-1}^{N} (r_i - \bar{r})^2}{N - 1}}$$

Whereas:
$\tilde{\sigma}$ = the standard deviation; the square root of the variance, of the return of the time charter contract

According to formulas 5, 6, and 7, the risk and return are calculated for a 3-year VLCC time charter vessel performing the MEG to FE route and a 1-year VLCC time charter vessel performing the WAF to FE route, shown in Table 11. It can be observed that the 3 year VLCC time charter vessel on MEG/FE route has a higher return as well as the higher volatility than the 1-year VLCC time charter vessel on WAF/FE route.

Table 11: Return and risk of the time charter contracts (Dec. 2001 ~ Feb. 2011)

	3 year VLCC TC on MEG/FE	1 Year VLCC TC on WAF/FE
Return	87.06%	24.59%
Risk	51.25%	37.00%

The return profiles of each time charter contract on the destined route are presented in Fig. 17 and Fig. 18. Meanwhile, Table 12 presents detailed statistical information of the two distributions.

Figure 17: Fluctuation of the return of 3-Year VLCC TC on MEG/FE market (Dec. 2001 ~ Feb. 2011)

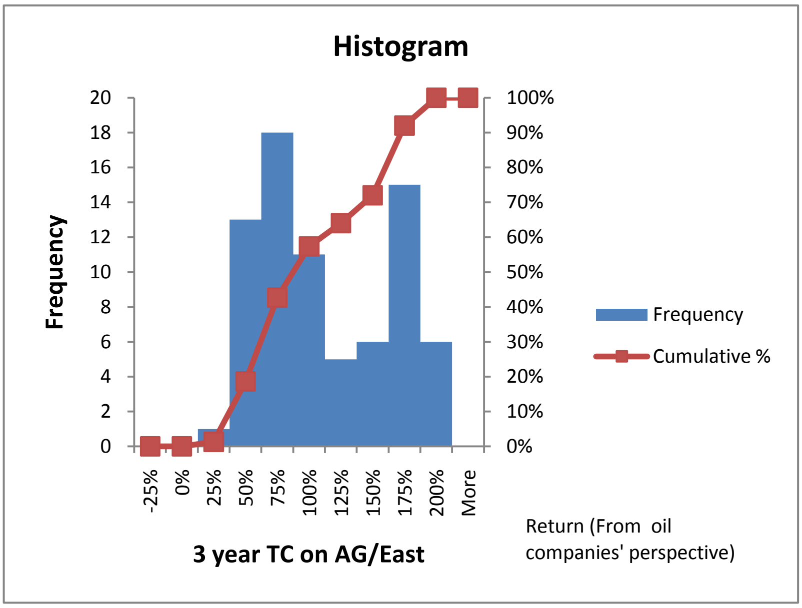


Figure 18: Fluctuation of the return of 1-Year VLCC TC on WAF/FE market (Dec. 2001 ~ Feb. 2011)

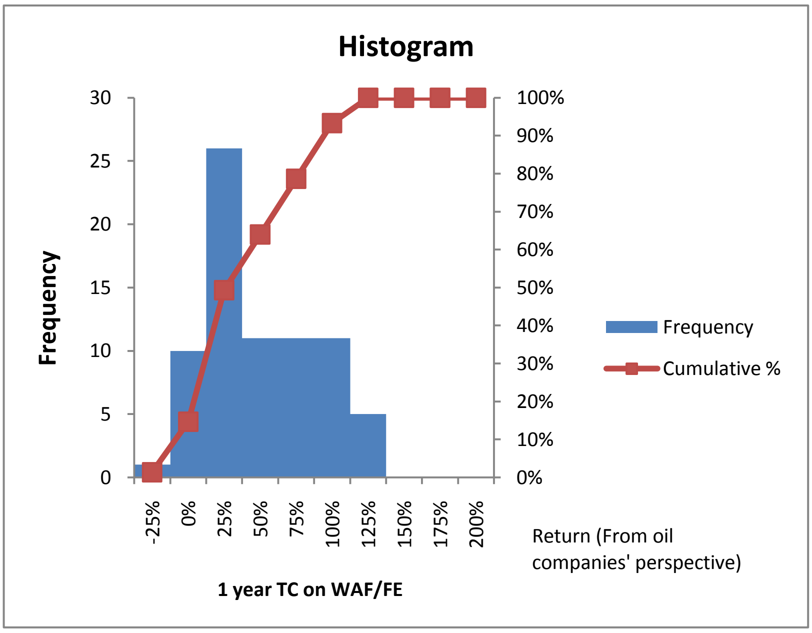


Table 12: Descriptive statistics (Dec. 2001 ~ Feb. 2011)

VLCC 3 Year TC (on MEG/FE market)		VLCC 1 Year TC (on WAF/FE market)	
Mean	87.06%	Mean	24.59%
Standard Error	5.92%	Standard Error	4.27%
Median	72.47%	Median	12.99%
Standard Deviation	51.25%	Standard Deviation	37.00%
Sample Variance	26.26%	Sample Variance	13.69%
Kurtosis	-1.39	Kurtosis	-0.92
Skewness	0.32	Skewness	0.41
Range	1.73	Range	1.35
Minimum	6.81%	Minimum	-37.61%
Maximum	180.04%	Maximum	97.49%
Sum	65.30	Sum	18.44
Count	75	Count	75

Step 3: Calculate the Coefficient of Correlation and the Covariance of the Two Investments

The Coefficient of Correlation and the Covariance of the two investments are generated as Table 13 and Table 14.

Table 13: The Coefficient of Correlation

	VLCC 3 Year TC (on MEG/FE market)	VLCC 1 Year TC (on WAF/FE market)
VLCC 3 Year TC (on MEG/FE market)	1	
VLCC 1 Year TC (on WAF/FE market)	0.660405832	1

Table 14: The Covariance

	VLCC 3 Year TC (on MEG/FE market)	VLCC 1 Year TC (on WAF/FE market)
VLCC 3 Year TC (on MEG/FE market)	0.259107611	
VLCC 1 Year TC (on WAF/FE market)	0.123537749	0.135050872

The Coefficient of Correlation between the two investments is less than 1, implying there will be some risk reduction effect. The calculation of covariance for the two investments is for the calculation of portfolio risk shown in the next step.

Step 4: Calculate the portfolio reward and risk

The portfolio reward can be calculated by applying Formula 3 which yields a reward of 68.94% which is the weighted return of the two investments.

$$\mathrm{E}(\mathrm{r_p}) = \mathrm{x_a E(r_a)} + \mathrm{x_b E(r_b)} = \mathbf{68.94}\%$$

The portfolio risk (standard deviation) is 44.13% which represents the square root of the portfolio variance, calculated by applying Formula 5.

$$\sigma_{\mathrm{p}}{}^2 = (\mathrm{x_a}\sigma_{\mathrm{a}})^2 + (\mathrm{x_b}\sigma_{\mathrm{b}})^2 + 2\mathrm{x_a x_b COV_{a,b}} = 19.48\%$$

$$\sigma_{\mathrm{p}} = 44.13\%$$

Calculating the risk and reward for a shipping contract portfolio provides some insight into the attractiveness of a portfolio. By repeating steps 1 to 4 one could obtain the portfolio risk and reward for different contract mixes and evaluate which chartering strategy is preferable given the required return and risk level.

5.3 The Optimal Reward and Risk Profile

The optimal return and risk profile could be obtained with the optimal contract mix modeling introduced in section 4.2.1 and by applying the Excel add-in Solver including the use of a special function “Quad product”.

Under the condition that company A requests to minimize the portfolio risk while having at least 45% of portfolio return on its time charter investment, the optimal reward and risk profile for company A is to have a contract mix consisting of 2% 1-year VLCC time charter on MEG/FE market, 28% 1-year time charter on WAF/FE market, and 70% 3-year time charter on WAF/FE market. The portfolio risk (standard deviation) will be 36.26%. The portfolio risk is less than the weighted average risk of each investing target since the risk is diversified. It is thus recommended to invest in more than 1 type of time charter contract for different markets to reduce overall portfolio risk.

5.4 Efficient frontier

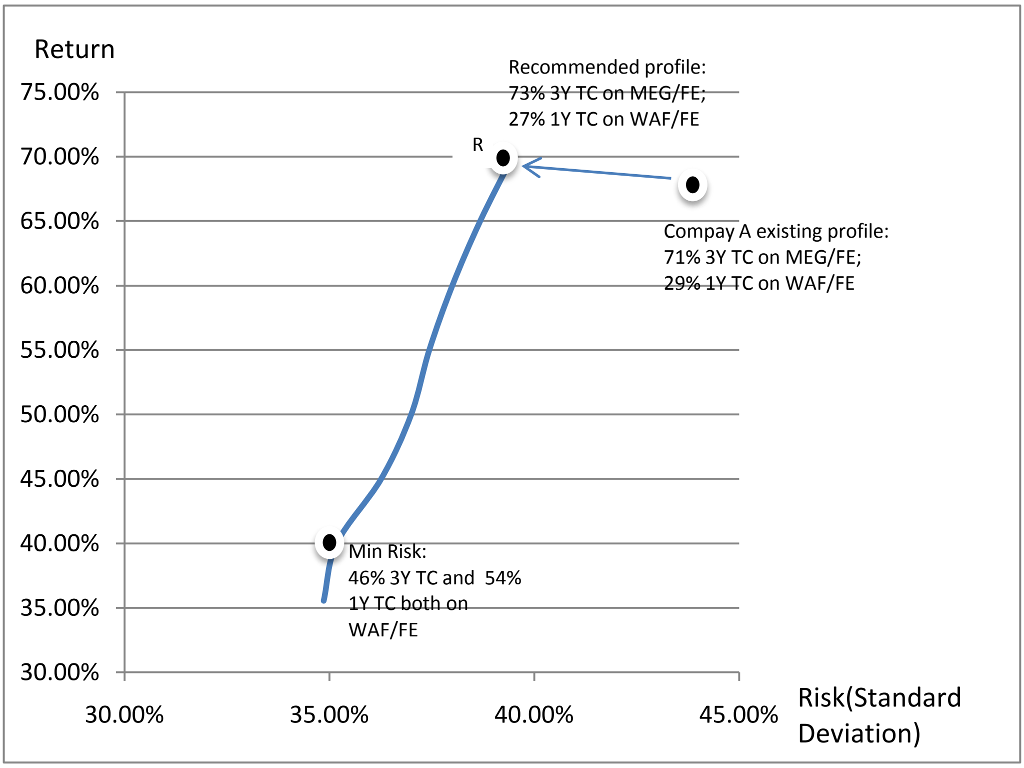
Using the Excel add-in Solver Table one can obtain the efficient frontier of shipping contract mix of company A, shown in Table 15 Company A could choose any efficient contract portfolio satisfying its return and risk conditions.

Table 15: Company A shipping contract mix efficient frontier

VLCC TC 1-Year on AG/FE Market	VLCC TC 3-Year on Ag/FE Market	VLCC TC 1-Year on WAF/FE Market	VLCC TC 3-Year on WAF/FE Market	Risk (St. Dev.)	Expected Return	Note
0%	71%	29%	0%	44%	69%	Present profile
0%	0%	61%	39%	35%	36%	
0%	0%	61%	39%	35%	36%	
0%	0%	61%	39%	35%	36%	
0%	0%	61%	39%	35%	36%	
0%	0%	61%	39%	35%	36%	
0%	0%	61%	39%	35%	36%	
0%	0%	46%	54%	35%	40%	Min risk
2%	0%	28%	70%	36%	45%	
0%	41%	59%	0%	37%	50%	
0%	49%	51%	0%	37%	55%	
0%	57%	43%	0%	38%	60%	
0%	65%	35%	0%	39%	65%	
0%	73%	27%	0%	39%	70%	Recommended

It can be observed from Fig. 19 that the present shipping contract profile (71% 3-Year TC on AG/FE and 29% 1-Year TC on WAF/FE) is not optimal. A slight shift towards the efficient frontier could either increase the portfolio return or decrease the portfolio risk. For instance, the profile of point R with 70% expected return and 39% risk is obviously better than the existing profile with 69% return and 44% risk. If the management could undertake 39% risk level, we would advise company A to alter its contract mix target to point R as to optimal the return and risk profile.

Figure 19: Company A shipping contract mix efficient frontier



5.5 Utility Analysis

Although the efficient frontier of a company's shipping contract is generated, we still do not know clearly what would be the "best" portfolio in the eyes of the management level of Company A. Whether one contract mix option may be better than another is a matter of satisfaction that a company receives from choosing a certain contract mix; in other words the company's "utility." To account for the role of utility in analysis of shipping contract portfolios a simple method is hereunder proposed. The main concept of the analysis is to reflect the satisfaction level by considering not only the risk and reward profile but also the risk preference or risk tolerance of the management level. The calculations for the risk penalty and utility are as follows.

$$\text{Risk penalty} = \frac{\text{Variance of return of the portfolio}}{\text{Risk tolerance}}$$

$$\text{Utility} = \text{Expected return} - \text{Risk penalty}$$

Risk penalty, depending both on the portfolio risk and on the investor' risk tolerance, is an adjusted factor reflecting the utility of a company by investing in a shipping contract portfolio. Risk tolerance is measured on a scale between 0 and 100. The higher the risk tolerance level, the higher risk the company is willing to bear. The "best" shipping contract portfolio for company A would be the one from the efficient frontier (section 4.2.1) that maximizes utility, the relative satisfaction level.

Table 16 presents the utility analysis of five shipping contract portfolios on efficient frontier for company A. We assume the risk penalty for risk-averse type of management is 10, for risk-neutral 50, for risk-lover 90. Based on three levels of risk tolerance we generate different levels of utility under each shipping contract portfolio.

It can be observed that the higher the risk tolerance, the higher the utility when other variables maintain the same level. When the management style is risk-averse, all of the 5 portfolios provide negative utility to the company. It is not recommendable to charter in VLCC time charter contracts for the marine transport demand since the utilities are negative for all the five contract mix options, including portfolio 1, the portfolio that minimizes the risk. Instead this portfolio analysis recommends satisfying tanker transport demand using only short-term voyage charter contracts. When the management style is risk-neutral or a risk-lover, the utility of portfolio 5 (73% 3-Year time charter on MEG/FE market and 27% 1-Year on WAF/FE market) is the highest. Hence for risk-neutral and risk-lover management, portfolio 5 is the most suitable shipping contract mix, which is on the efficient frontier as well as maximizing the utility,

The result of the utility analysis happens to provide a solid answer for the general chartering patterns of oil companies in the category of "oil consumers" that heavily rely on sport market chartering. Since the portfolio risk for investing time charter contracts is too high and the risk tolerance level for oil consumers in general is low, the utility will most likely be negative. Therefore it may be of no value to engage in any long-term shipping contract unless a predictable future market development could be anticipated.

The risk tolerance level is generally higher for some other types of oil companies such as integrated oil companies and oil producers. It is natural for them to engage in any long-term contract since the utility level is likely to be satisfactory.

Table 16: The risk tolerance and utility

	Portfolio 1 (Min Risk)	Portfolio 2	Portfolio 3	Portfolio 4	Portfolio 5
VLCC TC 1 Year on MEG/FE Market		2%			
VLCC TC 3 Year on MEG/FE Market			49%	57%	73%
VLCC TC 1 Year on WAF/FE Market	46%	28%	51%	43%	27%
VLCC TC 3 Year on WAF/FE Market	54%	70%			
Total	100%	100%	100%	100%	100%
Expected Return	40%	45%	55%	60%	70%
Risk (St. Dev.)	35%	36%	37%	38%	39%
Risk Tolerance 1	10%	10%	10%	10%	10%
Risk Penalty 1	123%	130%	137%	144%	152%
Utility1	-83%	-85%	-82%	-84%	-82%
Risk Tolerance 2	50%	50%	50%	50%	50%
Risk Penalty 2	25%	26%	27%	29%	30%
Utility 2	16%	19%	28%	31%	40%
Risk Tolerance 3	90%	90%	90%	90%	90%
Risk Penalty 3	14%	14%	15%	16%	17%
Utility 3	26%	31%	40%	44%	53%

5.5 Conclusions of Chapter 5

In this chapter we provided a simplified shipping contract mix case study from an Asian oil company categorized as an “oil consumer” by applying the concept of coverage ratio, modern portfolio theory, non-linear mean variance modeling, and utility analysis. The results indicate that if the management has a low risk tolerance, it should not engage in any time charter contracts but should it have a mid or high risk level it should engage in 73% VLCC time charter on MEG/FE market and 27% VLCC time charter WAF/FE market; a contract mix that lies on the efficient frontier and maximizing the utility level. The process and result of the analysis can be regarded as a systematic approach for finding the optimal shipping contract mix and answers the research question of the study how an oil company chooses the optimal shipping contract mix to serve its chartering strategies.

6. Conclusions and Suggestions

The paper firstly presents the general chartering strategy patterns for oil companies. From an oil supply chain perspective, oil companies are categorized into four groups- integrated oil companies, oil producers, oil consumers, and oil traders according to their main businesses along the supply chain. The participation level in tanker transport, patterns of contract mix, and the aim of their chartering strategies are identified for each category. Various internal and external factors influencing difference patterns of chartering strategies are then discussed.

The second part of the thesis focuses on a quantitative analysis to address the main research question that how an oil company choose the optimal shipping contract mix to serve its chartering strategies and determine optimal shipping contract portfolios which serve the oil company's strategic needs. Modern portfolio theory is elaborated as the main methodology to approach the analysis. A case study is provided to apply the theory to find the existing reward and risk profile, the optimal reward and risk profile that minimizing the portfolio risk, the efficient frontier of the shipping contract mix, and the utility levels subject to different degrees of risk preference.

To conclude, in order to find the optimal chartering strategy for a oil company it is first necessary to identify the company's profile by looking at where it fits in the oil supply chain based on its business activities. Secondly, the company is benchmarked against other similar market players to identify the level of participation in oil transport and general patterns of chartering strategies. To find the detailed percentage for the shipping contract mix, the quantitative modeling could then be applied as a reference in support of chartering decisions.

Suggestions for Future Research

The approach we have carried out for the analysis of the optimal shipping contract mix has a few constraints and is suggested to be perfected for the future research. Firstly, portfolio theory implies that the distribution pattern from historical data is also applicable for the future development; but it may hardly be true in reality. Thus the analysis based on portfolio theory could at most be a strong systematic reference for chartering decisions. Secondly, the portfolio approach and the mean variance model we proposed are both static. A useful extension for the future research would be to develop a multi-period analysis to determine the optimal shipping contract mix for rebalancing portfolio continuously.

Bibliography

Awerbuch, S. and Berger, M. (2003). ‘Energy Security and Diversity in the EU: a Mean–Variance Portfolio approach’. IEA Research Paper, Paris, February 2003.

Ansari, Z. M. (2007) ‘*Portfolio Risk Management in Shipping Real Assets and Shipping Security Assets*’. MSc Thesis. Rotterdam, The Netherlands: Erasmus University Rotterdam.

Berg-Andreassen, J. A. (1998). ‘A Portfolio Approach to Strategic Chartering Decisions’. *Port and Maritime Transportation Economics*, 25: 375-389.

Brown, G. G., et al (1987). ‘Scheduling Ocean Transportation of Crude Oil’. *Management Science*, 33: 335.

Bonser, J. and Wu, S. (2001) ‘Procurement Planning to Maintain both Short-Term Adaptiveness and Long-Term Perspective’. *Management Science* 47: 769-786.

Brealey, R. et al. (2008). *Principles of Corporate Finance.* New York: Business Book.

Christiansen, M., et al (2004). ‘Ship Routing and Scheduling: Status and Perspectives’. *Transportation Science*, 38: 1-18.

Christiansen, M., et al (2007). ‘Ship Routing and Scheduling with Flexible Cargo Sizes’. *Journal of the Operational Research Society*, 58:1167-1177.

Charnes, A., et al (1954). ‘A Model for Programming and Sensitivity Analysis in an Integrated Oil Company’. *Econometrica*, 22:193-217.

Cheng, L. and Duran, M. A. (2004). 'Logistics for World-wide Crude Oil Transportation Using Discrete Event Simulation and Optimal Control'. *Computers and Chemical Engineering*, 28:897-991.

Cohen, M. and Agrawal, N. (1999). 'An Analytical Comparison of Long and Short Term Contracts'. *IEE Transactions* 31: 783-796.

Clubley, S. (1998). *Trading in Oil Futures and Options*. Cambridge: Business Books.

Erhun, F., et al (2000). 'Spot Markets for Capacity and Supply Chain Coordination'. Working Paper, Carnegie Mellon University.

Fagerholt, K., et al (2010). 'A Decision Support Methodology for Strategic Planning in Maritime Transportation'. *Omega,* 38:465-474.

Hillier, F. and Hillier, M. (2003). *Introduction to Management Science.* New York: Business Book.

Markowitz, H. (1952). 'Portfolio Selection'. *Journal of Finance*, 7:77-91.

Powell, B. J. (1997). 'Fleet Deployment Optimization for Liner Shipping: an Integer Programming Model'. *Maritime Policy Management*, 24: 183-192.

Taylor, AJ (1981). 'Chartering Strategies for Shipping Companies'. *Omega*, 10:25-33.

Stopford, M. (2010). *Maritime Economics*. London: Business Books.

Shen, A. and Vogiatzis, A. (2004). '*Portfolio risk management in shipping and optimal asset allocation*'. MSc Thesis. Rotterdam, The Netherlands: Erasmus University Rotterdam.

Spinler, S. and Huchzermeier, A. (2006). ‘The Valuation of Options on Capacity with Cost and Demand Uncertainty’. *European Journal of Operational Research*, Volume 171, Issue 3: 915-934.

Serel, D., et al. (2001). ‘Sourcing Decisions with Capacity Reservation Contracts.’ *European Journal of Operational Research*, 131:635-648.

Incoterms 2010. http://www.iccwbo.org/incoterms/