THE DYNAMICS OF SHIPBUILDING IN SHIPPING:
AN ECONOMETRIC ANALYSIS

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CERTIFICATE OF ORIGINALITY

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Jane Jing Xu

ABSTRACT

In this thesis, we perform an empirical analysis of the role of shipbuilding in the large shipping world. Shipbuilding has scarcely been studied from the economic perspective in shipping related literatures; most studies only involve shipbuilding as related variables when discussing other shipping markets. A large amount of studies on shipping markets are based on the efficient market theory. However, given the unpredictable and ever-changing nature of shipping industry, it is not convincing to study the market statically, we focus specifically on the factor of 'time lag' between different shipping segments through a comprehensive econometric analysis.

We look into the dynamics between freight and shipbuilding markets in a more delicate way: the interaction among freight rate, shipbuilding order and delivery. Our first research question concerns the causal mechanism from freight rate to shipbuilding price and indicates that the investment behaviour in physical assets for future service capacity is encouraged by a strong service market. The second research question discusses the determinants of shipbuilding activities. Through pooled panel data analysis, we verify the important role of freight market to the ship investment decision and the strong cluster effect of Asian shipbuilding countries. Our third research question looks into

the impact of the change of fleet size on freight volatility. Our results prove that fleet size is a critical determinant of freight volatility and affects it in a nonlinear manner.

Our study contributes to the maritime economics literature by providing a comprehensive economic analysis of shipbuilding. Shipbuilding variables do not interact with other economic variables in a static way, hence time lag issues need to be largely considered in the analysis. The dynamics among freight rate, shipbuilding order and delivery act in a cyclical manner. While the shipbuilding market largely depends on the operating environment of other shipping markets, it influences back freight market profoundly.

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Last but not least, I thank my Heavenly Father for carrying me all the way through. I pray that I can glorify Him with everything I do.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

ARCH – Autoregressive Conditional Heteroskedasticity Model
BDI – Baltic Dry Index
BFI – Baltic Freight Index
CAPM – Capital Asset Pricing Model
CGT – Compensated Gross Tonnage
DWT – Dead Weight Tonnage
EMH – Efficient Market Hypothesis
FDI – Foreign Direct Investment
FFA – Forward Freight Agreement
GARCH – Generalized Autoregressive Conditional Heteroskedasticity Model
GDP – Gross Domestic Product
GDPPC – Gross Domestic Product per Capita
GLS – General Least Squares
GMM – Generalized Method of Moments
OLS – Ordinary Least Squares
SIC – Schwarz Information Criterion
TC – Time Chater
VAR – Vector Autoregressive
VECM – Vector Error Correction Model
SD – Standard Deviation
S&P – Sales and Purchase

1 INTRODUCTION

Meersman et al. (2009) depicted a picture of potential development in shipbuilding in the book *Future Challenges for the Port and Shipping Sector*. Three main variables were considered to drive the future of shipbuilding: economy, ecology and technology. Reviewing the shipbuilding related literatures, shipbuilding economics has been the least studied. In this thesis, shipbuilding is studied in a wide context from the economic perspective. Shipbuilding is not a decisive driver in the future of the shipping and port sector. It is flexible enough to react to the demands of ships. It may react with different price settings in other markets. However, shipbuilding is so important that it shapes the fortunes of the wider shipping market, and changes the economic picture of the whole shipping world for the next decade. What happens in shipbuilding market will not only affect ship builders in the next couple of years, it will decide the market demand and supply situation.

1.1 Background

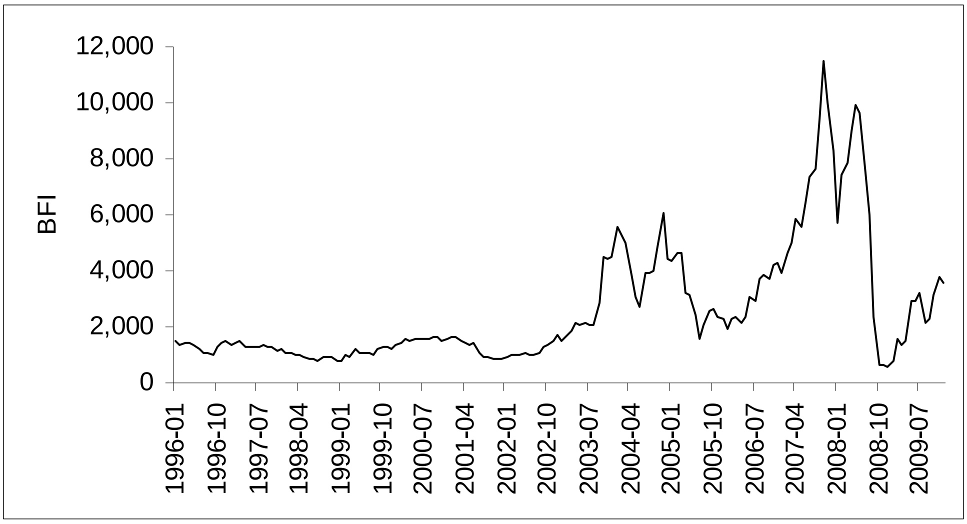
1.1.1 Cyclical nature of shipping industry

Shipping industry is a capital intensive industry. A ship functions on two levels in shipping markets: firstly, it is an asset in the capital market. The sale of one merchant ship is a large capital transaction and involves generally millions of US dollars. The capital involved in the shipbuilding process is a huge amount of sunk cost, owning a large and expensive item of capital investment already involves a lot of risk. Secondly, a ship contributes to the supply of carrying capacity in the freight market. In most cases, the shipowners do not invest in ships for speculative purposes; they focus more on the future payoff by chartering out ships in the freight market. To choose a right time to build new ships is essential in this circumstance: since new ships need to be designed, constructed and commissioned before coming into services, the duration from order to final delivery may take two years or longer. When the ship is delivered, the market situation may become totally different. The cyclical nature of shipping market decides the shipping risk (Stopford, 1997).

In this sense, the shipping industry is highly volatile/risky in nature, and this risky nature originates from the building of new ships. Just last year, the shipbuilders were receiving the largest commercial orderbook in history, and the whole industry was expecting another blossom. However, what they eventually encountered was the global financial crisis, followed by plummeting prices, large scale cancellations, endless delivery delays, and devastating financial situation. Shipping risk is what the shipping cycle is all about. As Stopford (1997) mentioned, ‘Cycles play a central part in the economics of the shipping industry by managing the risk of ship investment in a business where there is great uncertainty about the future.’

In any market including shipping market, the market cycle goes through the four stages: trough, recovery, peak and collapse. Examining the past data of Baltic freight index of more than 20 years (see Figure 1-1), there is no firm cyclical pattern of shipping market, i.e. the length and the timing of different stages. Besides, the return on investment in shipping has a poor track record in terms of low financial returns and high risks. One may ask, why do people still want to invest ships?

Figure 1-1 Baltic freight index (1996:01-2009:12)



Source: Clarkson’s Shipping Intelligence Network

Risk is what investors try to avoid, however, the highly risky nature of shipping market at the same time actually attracts ship investors. Due to the highly capital intensive nature of shipping market, the winners in the game can gain enormous wealth.

However, one’s massive profit is at the cost of many others’ great loss. Given the right timing and strategy, one may easily make a great fortune in shipping market; likewise, one may lose the whole game in a short time. We are motivated to study the risky nature of shipping industry in this study to guide ship investment decisions.

1.1.2 Four shipping markets

There are four shipping markets in shipping, trading different commodities: sea transport for freight market, second-hand ships for Sale and Purchase (S&P) market, new ships for shipbuilding market and scrap ships for demolition market. The four shipping markets interact with each other and together make the shipping industry function. In this thesis, we focus on the freight and shipbuilding markets, which are the two shipping markets causing major cash flows.

1.2 The Freight Market

The freight market trades sea transport service. Freight rates in the sea freight market are determined as the interaction of the supply and demand for cargo carrying services.

Freight rates have been considered the most critical indicators for shipping markets because they represent the principal source of earnings for the shipping industry. The freight market has also been studied most among the four shipping markets. Existing studies on the freight market have focused on the characteristics of shipping freight rate, such as freight volatility and risk *(Kavussanos, 1996;* Adland and Cullinane, 2005; *Koekebakker, Adland and Sodal, 2006*), cointegration (*De Borger and Nonneman, 1981*) and term structures (*Kavussanos and Alizadeh, 2002; Veenstra, 1999*), and looked at factors influencing the freight rates (*Hawdon, 1978; Beenstock and Vergottis, 1993).*

These studies showed that the freight rate is not stationary like most economic and financial time series (see *Kavussanos and Visbikis, 2006*; *Alizadeh and Nomikos, 2009*) and that the freight rate is determined by the demand for trade, the supply of ships and other macro-economic factors of the sea freight market (for example, *Hsu and Goodwin, 1995; Evans and Marlow, 1990*).

1.3 The Shipbuilding Market

The shipbuilding market trades new ships and brings about cash inflow to the shipping industry. Shipbuilding market is unique in many ways: it is in a way more complex than the sale and purchase market since it involves the whole process of building new ships from ship design to delivery. According to Bruce (1999), the shipbuilding process consists of five steps: contract design, basic design, detailed design, parts manufacturing and assembly. The duration may take one to two years. The capital involved in the shipbuilding process is a huge amount of sunk cost. Shipbuilding is a very attractive industry for a country as it can bring a substantial amount of foreign direct investment. Japan relied on shipbuilding in the 1950s and 1960s to rebuild its heavy industrial capacity. Shipbuilding domino effect has been observed by the industry: the types of ship and the yards building them are widely different, however, the prices of different types of ships tend to co-move along the time. This shows the information transparency of shipbuilding market, namely, a perfectly competitive market (*Dikos, 2004*).

Shipbuilding has not been known as a decisive driver in the future of the shipping and port sector. Many studies discussed shipping economics and focused on freight market exclusively (for example, *Hawdon, 1978; Beenstock and Vergottis, 1993*). Shipbuilding was only involved in these studies as related variables. However, the reason why shipbuilding market is so important is that what happens in shipbuilding does not just affect ship builders; shipbuilding is the primary means of changing the supply of cargo carrying capacity of the shipping industry, thus in turn changing the economic picture of shipping markets in all.

Shipbuilding has mostly been studied from the following three perspectives: technology, ecology and policy, i.e. technology advances, environmental issues and incentive policies. Shipbuilding has seldom been studies from the angle of economics. The exceptions are the pricing of ships as a capital asset, with the asset pricing determined by measuring the net present value of expected earning potential (for example, *Dikos, 2004; Alizadeh and Nomikos, 2007*). Shipbuilding price is claimed to depend on the balance between supply and demand of shipbuilding capacity. The existing literature contributes to the forecasting of ship prices, however, the dynamics between shipbuilding market and other markets and the possible impact brought by what happens in shipbuilding market are left unexamined.

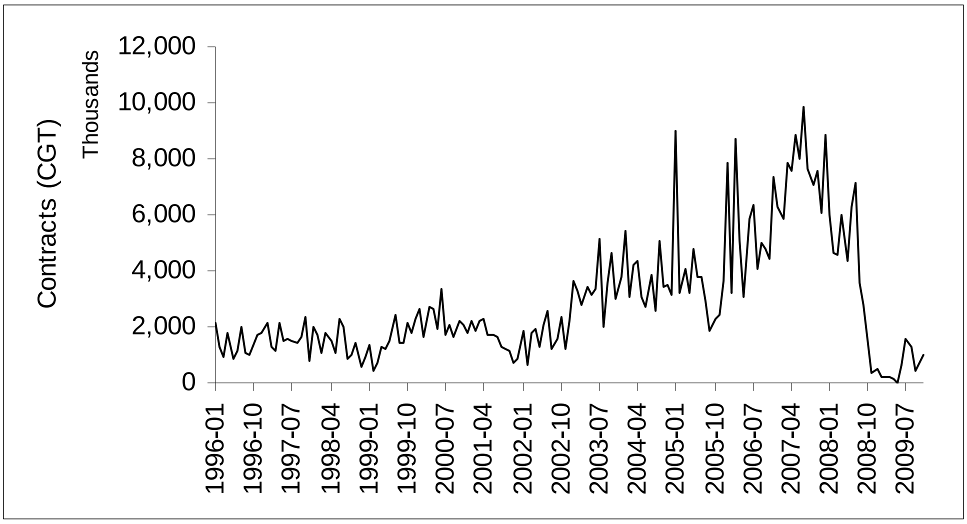
1.4 Shipbuilding Evolution from 1996 to 2009

Most of the shipbuilding related literatures look into the period before the early 1990s (Beenstock and Vergottis, 1989; Marlow, 1991). From the early 1990s, the shipping and shipbuilding world has gone through tremendous changes. In this thesis, we study the more contemporary shipping world ranging from 1996 to 2009. Figures 1-1 to 1-3 show the changes of freight rate, shipbuilding output, and shipbuilding rate from 1996 to 2009. There was a peak of dry bulk freight rate in 1995, the recovery of freight rate triggered a huge orderbook of new ships, and deliveries began to build up in 1996.

However, beginning in July 1997, the Asian Financial Crisis spread around much of Asia, and lead to worldwide economic meltdown due to financial contagion. Trades between countries were cut down, which leads to a lack of demand for sea transport. At the same time, a large amount of ships ordered during peak years of 1995 and 1996 were delivered to the market. Lack of demand and oversupply of ships led to a substantial drop in freight rate and subsequently in shipbuilding price. The shipbuilding price was further lowered because of the rising role of South Korea in shipbuilding industry. South Korea was expanding its shipbuilding capacity at that time and was offering competitive shipbuilding price much lower than other countries. This also started the decline of European shipyards. Shipping industry started recovering in early 2000, however, later after the September 11, 2001 event, the world economy was again in recession and the shipping world was no exception. In 2003, the growth of Chinese economy gave impetus to shipping industry, China's large demand for iron ore made 2003 one of the best years for bulk carriers. As shown in Figures 1-1 to 1-3, the shipping market kept rising from 2003 to early 2008, with the exception of a cooling down in 2005. Shipbuilding output, freight rate and shipbuilding price reached a peak in mid 2008. The global financial crisis hit the world in 2008, caused by the United States Sub-prime crisis. The world economy plummeted, and the global shipbuilding industry since then has not been in a state of euphoria as in earlier days.

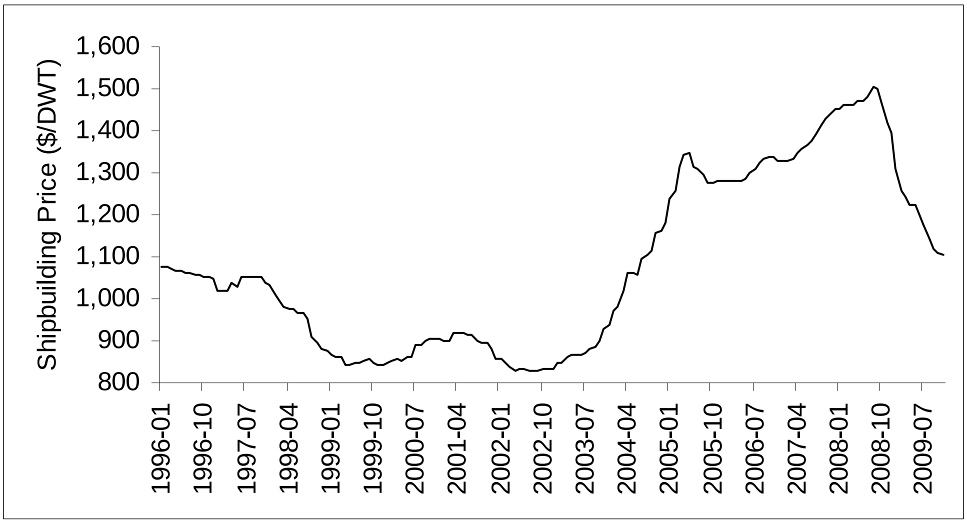
The contract volume of booked new ships dropped dramatically after August 2008, and not a single contract was received by worldwide ship builders for a whole month of May 2009. Ship investors and Ship manufacturers through the whole world are in a distressful situation. We are now still in the wake of financial crisis (BRS report, 2009), we are hereby also motivated in this thesis to discuss the critical factors that can save shipbuilding industry from the distress.

Figure 1-2 The amount of contracts worldwide (1996:01-2009:12)



Source: Clarkson's Shipping Intelligence Network

Figure 1-3 Average shipbuilding prices (1996:01-2009:12)



Source: Clarkson’s Shipping Intelligence Network

In terms of major shipbuilding countries, Figure 1-4 shows the share of shipbuilding contracts received by Japan, South Korea, China, Europe and other areas from 1996 to 2009. Table 1-1 shows contracts received by country of build in 2008.

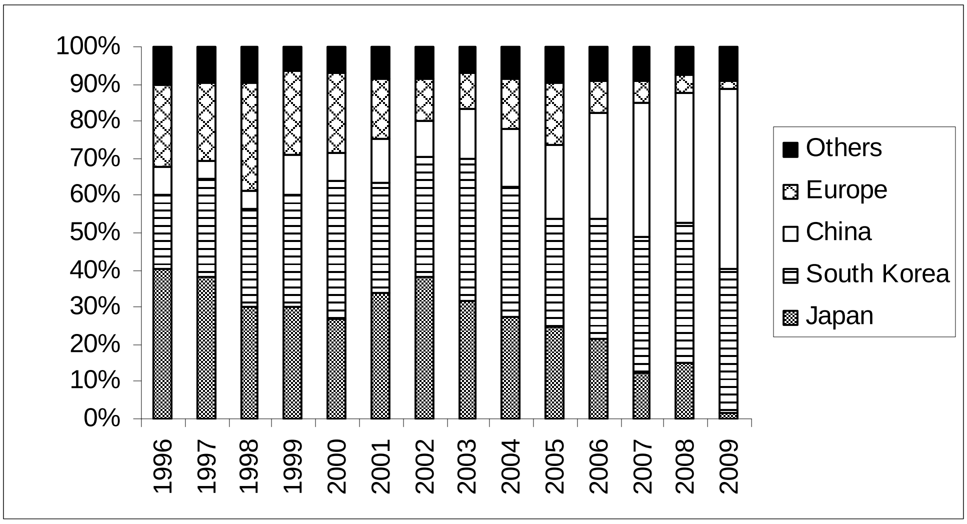
Prior to 1965 Europe had by far the largest market share. The United Kingdom was the leading shipbuilder in the first half of 20th century. The production at West European shipyards declined dramatically in later years, European shipbuilding acted the contrary to China’s case during this period of 1996 to 2009. It has lost most ground to the three Asian countries. The loss for European shipyards meant a gain for other countries, in particular Japan, South Korea and China. European shipbuilding countries now tend to focus on high-value added segments.

Japan has a long history of shipbuilding and by far still maintains its shipbuilding output share. It relied on shipbuilding in the 1950s and 1960s to rebuild its heavy industrial capacity. It is the first country to challenge the European yards, and received 40% of the contracts received worldwide in 1996.

South Korea made shipbuilding a strategic industry for economic development in the 1970s. Japan soon lost ground to South Korea, which has aggressively expanded its shipbuilding capacity and has become the largest shipbuilding country in 2003 and remained to till 2008.

At present, China follows a similar pattern of shipbuilding developments in Japan and Korea. These countries are in turn challenged by China, whose amount of contracts has already surpassed South Korea in 2009 and is still growing with a fast pace. China is poised to take 40% of the market by 2020 (Drewry Shipping Consultants Ltd, 2009).

Figure 1-4 hare of contracts of shipbuilding by country/area



Source: Clarkson's Shipping Intelligence Network

Table 1-1 Shipbuilding contracts by country of build (2008)

Country	*DWT*	*Percentage*
Brazil	241,362	0.14%
Denmark	23,000	0.01%
Finland	10,000	0.01%
France	600	0.00%
Germany	468,550	0.28%
Italy	65,000	0.04%
Japan	25,976,539	15.46%
Netherlands	231,470	0.14%
Norway	56,300	0.03%
P.R. China	61,748,392	36.74%
Poland	82,100	0.05%
South Korea	69,411,961	41.30%
Spain	144,200	0.09%
Turkey	771,600	0.46%
USA	56,670	0.03%
Total		94.78%

Source: Clarkson's Shipping Intelligence Network

1.5 Structural Modelling of Shipping Markets

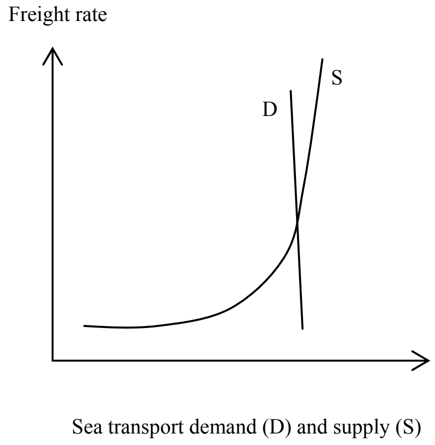
Beenstock and Vergottis (1993) published the book *Econometric Modelling of World Shipping*, in which they developed a complex of econometric models for ship prices relating freight market, second hand markets, shipbuilding market and scrap market. This book is a milestone of the modern analysis of bulk shipping markets. This book fully included structural econometric models for bulk shipping market based on market efficiency theory. Structural modelling is popular among early shipping economic studies (Hawdon, 1978; Charemza and Gronicki, 1981; Beenstock and Vergottis, 1989).

1.5.1 Freight related models

According to Beenstock and Vergottis (1993)'s book, the freight rate is determined by the equilibrium of the inelastic demand (in tonne miles) and the supply of ship services (carrying capacity by the fleet tonnage). Demand for shipping is considered to be exogenous, since it is treated as being inelastic to freight rate. For time charter rate and spot rate, time charter rate is believed to reflect spot charter rate over the same duration. Present time charter rate is positively related to the present expectation of next period's spot rate, and negatively related to next period's bunker price. Other studies focusing on the factors influencing the freight rate drew similar conclusion that the freight rate is determined by the demand for trade, the supply of ships and other macro-economic factors of the sea freight market (*Hawdon, 1978; Hsu and Goodwin, 1995; Evans and Marlow, 1990*).

Stopford (1997) described the basic shipping supply and demand functions as shown in Figure 1-5. The fleet supply function (S) is a hockey stick shaped curve, it works by moving ships in and out of service in response to freight rate. The ship supply function is elastic when freight rate is low and inelastic when freight rate is high. The fleet demand function (D) is almost vertical, it shows how charterers adjust to changes in freight rate. Due to the lack of alternative transport mode, shippers ship the cargo regardless of the cost.

Figure 1-5 Shipping supply and demand functions



Source: Maritime Economics (Stopford, 1997)

1.5.2 Shipbuilding related models

Beenstock and Vergottis (1993)'s book models the supply of new ships based on the assumption of profit maximisation of ship builders. Shipbuilding output is related to the price of new ships, various inputs for shipbuilding (such as labour, metals, energy and land) and previous shipbuilding output values. Shipbuilding prices are discussed and modeled in a close correlation to second hand ship prices.

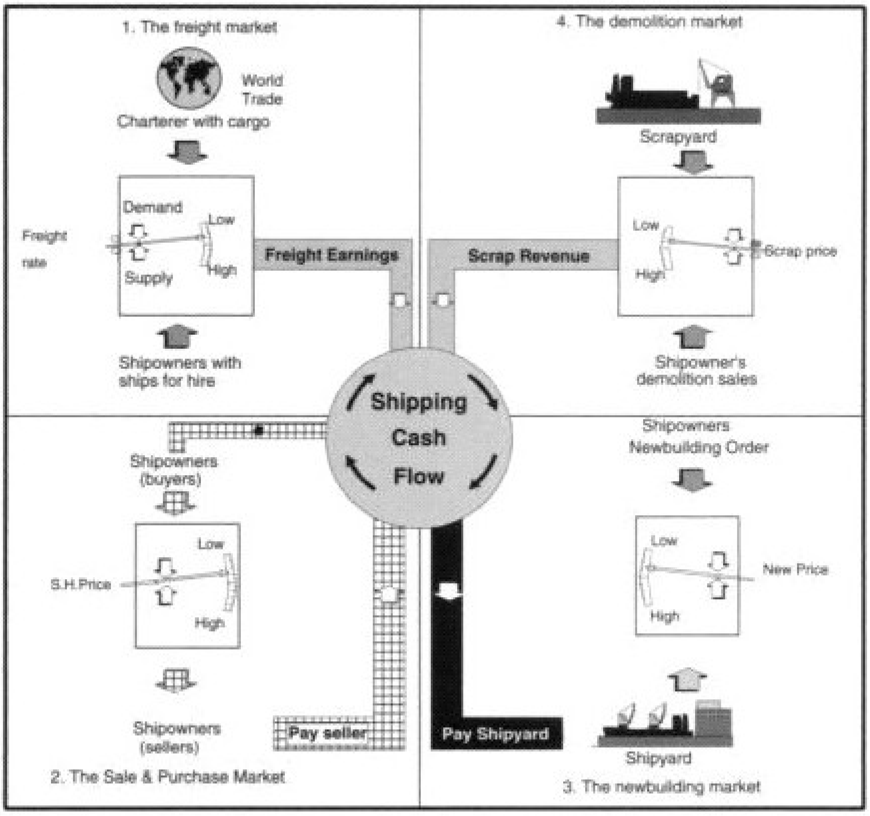
Beenstock and Vergottis (1989, 1993) studied freight and shipbuilding through structural modelling. Most shipbuilding related modelling only involved shipbuilding as related variables rather than discussing it exclusively (Bessler, Drobetz and Seidel, 2008; Engelen, Meersman and Van de Voorde, 2006; Nielsen, Kristensen, Bastiansen and Skytte, 1982). If we attempt to understand the inherent nature within market or the dynamics between markets, more advanced econometric techniques are needed to analyse the market nature and dynamics.

1.6 New Research Perspectives on Shipbuilding Market

1.6.1 Cash flow and time lags among four shipping markets

As previously mentioned, there are four shipping markets in shipping trading different commodities: sea transport for freight market, second-hand ships for S&P market, new ships for shipbuilding market and scrap ships for demolition market. Stopford (1997) described the cycle of the four shipping markets (Figure 1-5): at the beginning when shipping supply cannot catch up with demand in freight market, freight rates rise and cash starts to flow into the cycle. Shipowners thus have the financial confidence to buy second-hand ships in S&P market, or order new ships due to the economic reasons or lack of appropriate second-hand ships. With more and more arrival of shipbuilding ships after a period of time, shipping supply surpasses demand, freight rates fall, the shipowners act reversely.

Figure 1-6 Cycle of four shipping markets



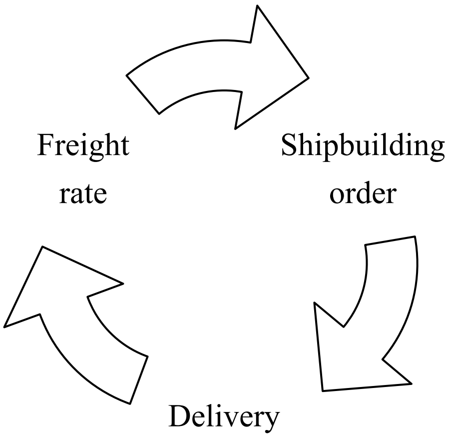
Source: Maritime Economics (Stopford, 1997)

We are aware of the fact that there are lead and lag relationships between different shipping markets. Since it takes time for market information to flow from one market to another, and the responding rate to new information varies across different shipping markets. The time lags were most often discussed between markets in the literature. However, in terms of freight market and shipbuilding market, we realise that time lag between the two markets actually acts in a more delicate way. We choose the three most commonly discussed variables in these two markets: freight rate, shipbuilding order and delivery and illustrated the time lag or dynamics among them in Figure 1-6.

1.6.2 Time lags among freight rate, shipbuilding order and delivery

Figure 1-6 illustrates the dynamics among freight rate, shipbuilding order and delivery. First, the cash flows from freight rate (the freight market) to shipbuilding orders (the shipbuilding market). Often there is a lag between these two markets, since it takes time for the market information to deliver and the ship-owners to perceive. Second, after the shipowners make the decision to build new ships, the new ships need to be designed, constructed and commissioned before coming into services, the duration from shipbuilding order to final delivery may take two years or longer. Third, when the ship is delivered, it immediately constitutes the new ship supply of the market, the fleet size trading in the market thus changes, and in turn affects the fright rate, the freight market situation may become totally different by then. There are two lags in this cycle: from freight rate to shipbuilding order and from shipbuilding order to delivery.

Figure 1-7 Dynamics among freight rate, shipbuilding order and delivery



1.6.3 Dynamics between shipbuilding and other variables

Previous studies have been mainly about structural modelling of shipping markets. We can understand the basic relationships among variables through structural modelling, such as the sign and significance level of the variables. However, if we want to dig into the inherent nature and dynamic relationships between shipbuilding and other variables, new studies with different approaches are needed. Thus, rather than building a regression model, we focus on econometric analysis in this thesis, for example, the cause and effect relationship, investment timing and characteristics of the variables. We apply more advanced econometric analytical methods, such as time series techniques and panel data analysis. We will specifically discuss the methodology adopted for this study in Chapter 3.

1.7 Research Motivations and Objectives

We have discussed the importance of shipbuilding market in shipping industry in previous sections. Once the new ships are ordered, they will not only affect ship builders in the next couple of years, the delivery of them will decide the market demand and supply situation. Given the cyclical nature of shipping industry, we are motivated to study the risky nature of shipping industry in this study to guide ship investment decisions.

In terms of freight market and shipbuilding market, we realise that time lag between the two markets actually acts in a more delicate way. We are therefore also motivated to examine the time lag issues in shipping economic studies.

The objectives of this study are two-fold. The first objective is to bridge a gap in the literature by studying shipbuilding in a wide context from the macro-economic perspective. Reviewing the shipping related literature, most studies discussed shipping economics and focused on freight market exclusively. Shipbuilding was only involved in these studies as related variables. However, shipbuilding is such an important shipping market as it is where the shipping risk originates. We shift the research focus from the freight market to the shipbuilding market.

The second objective of this study is to provide a comprehensive analysis of the role of shipbuilding within the large shipping world. We change the research angle from structural modelling to dynamic analysis. A large amount of studies on shipping markets are based on the efficient market theory, which asserts that financial markets are "informationally efficient" and prices instantly change to reflect new public information (Malkiel, 1987). Simultaneous-equations macroeconomic models are found prevailing in early studies of shipping markets. However, shipping industry is known for its unpredictable and ever-changing nature. Time series models have been gradually developed to overcome the shortcomings of simultaneous models (Kavussanos, 1996; Veenstra, 1999). In this thesis, we focus specifically on the factor of ‘time lag’ between different shipping segments through time series analysis.

1.8 Research Questions

Previously we discussed the dynamics among freight rate, shipbuilding order and delivery as illustrated in Figure 1-6. We see two lags in this cycle: from freight rate to shipbuilding order and from shipbuilding order to delivery. We develop our three research questions accordingly.

The first research question concerns from freight rate to shipbuilding order. From the above cash flow analysis on the four shipping markets (see Figure 1-5), we understand that shipbuilding demand is a derived demand, as it depends mainly on the operating environment of the freight market, usually with a lag. It is believed that shipowners make the shipbuilding order of ships based on their judgment of the freight market situation (see Figure 1-6). The prosperity of the shipbuilding market is driven by freight rate, vessel demand in the freight market. Shipbuilding demand is a derived demand, as it depends mainly on the operating environment of the shipping market. While one can imagine the existence of a relationship between shipbuilding price and freight rate, the direction of causality between them is not known, that is, whether freight rate leads shipbuilding price or vice versa or a bidirectional causality exists. We hereby raise our research question 1:

> *Research Question 1: What is the directional causal relationship between the shipbuilding price and freight rate?*

Following the research question 1 about the relationship between freight market and shipbuilding market, we move on to the Shipbuilding order segment in Figure 1-6. Shipping industry is known as a capital intensive industry, the capital involved in the shipbuilding process is a huge amount of sunk cost, owning a large and expensive item of capital investment involves huge risk. There have been studies on modelling the shipbuilding prices and orders for new ships. However, few of them analysed how and why the amount of shipbuilding orders fluctuates dramatically over time. To our best knowledge, there is no rigorous study on the determinants of shipbuilding activities. We are intrigued to study the research question 2:

> *Research Question 2: Which variable/variables play the most important role in determining the amount of shipbuilding orders?*

Our third research question concerns with the closing arrow from delivery to freight rate. We mentioned that the duration from shipbuilding order to final delivery may take two years or longer. The delivery causes the change of the supply of fleet trading in the shipping markets, while the freight market situation may become totally different from the shipowners' expectations when they made shipbuilding orders. The highly volatile nature of freight rate is widely acknowledged, however, the impacts and the causes of the time-varying risk in shipping markets has been left unstudied. Of all the variables that might cause the high volatility of freight rate, fleet size is believed to be the one that changes most severely along the time, due to the habitual massive shipbuilding orders in shipbuilding market and the lag between the shipbuilding order and delivery. Therefore, we have our third and final research question:

Research Question 3: How does the fleet size affect freight rate volatility?

1.9 Thesis Organisation

This thesis consists of seven chapters. In Chapter 1 we have introduced the industrial and academic background, research objectives and research questions of this study. Chapter 2 reviews the literature relevant to shipbuilding from four perspectives: economics, policy, strategy and technology, and specifically lists the studies from economic perspective. Chapter 3 discusses the methodology commonly used in shipping economic studies, and then introduces the research methodology we adopt in this thesis. In Chapters 4 to 6, we present three research issues respectively corresponding to the three research questions. Chapter 4 studies the directional relationship of freight market and shipbuilding market; Chapter 5 analyses the determinants of shipbuilding activities; Chapter 6 discusses the impact of the change of fleet size on freight volatility. In Chapter 7, we summarise the main findings of this study, discuss implications and limitations, and identify the future research direction.

2 OVERVIEW OF SHIPBUILDING LITERATURE

This chapter reviews the literature relevant to shipbuilding from four perspectives: economics, policy, strategy and technology. There are relatively fewer studies on shipbuilding from the perspectives of strategy, policy and economics. We specifically list the studies related to shipbuilding from economic perspective.

2.1 Introduction

Shipbuilding is known as an attractive industry for nations under development. Take the three largest shipbuilding countries for example, Japan used shipbuilding in the 1960s to rebuild its industrial structure; South Korea made shipbuilding a strategic industry in the 1970s, and is by far the world's largest shipbuilding nation; China now keeps pace with these two countries and is predicted to overtake South Korea in the near future. The traditional European maritime countries were the leading shipbuilders in the first half of 20th century. Now the entire European countries' total market share has fallen to a tenth of South Korea's. This illustrates shipbuilding industry's significance to a country's early development.

The shipbuilding market brings about cash inflow to the shipping industry through trading new ships. It also reflects a major change on the market supply of ships. The reason why shipbuilding market is so important is that it may change the economic picture of the entire shipping world. Since what happens in shipbuilding does not just affect ship builders; it is also the primary means of changing the supply of cargo carrying capacity of the shipping industry for the next decade. The shipbuilding market is in a way more complex than the sale and purchase market since it involves the whole process of building new ships from ship design to delivery and the duration may take one to two years.

Shipbuilding has been studied in the literature from the following four perspectives: economics, policy, strategy and technology. Most studies focus on the technological issues of shipbuilding, such as ship design and shipbuilding innovation (for example, Motora, 1997; Pires Jr., Lamb and Souza, 2009). There are relatively fewer studies on shipbuilding from the perspectives of strategy, policy and economics. We can find only a handful of studies discussing exclusively about shipbuilding economics, most studies only involve shipbuilding as related variables when discussing other shipping markets.

2.2 Economic Related Research

2.2.1 Shipbuilding

Tsolakis (2005) raised 3 major propositions of shipbuilding in his PhD thesis, namely, supply-demand proposition, cost based proposition, and asset pricing proposition.

The shape of the demand curve for shipbuilding has been studied by Stopford (2008) and others. When the shipbuilding price is high, the demand curve is of lower elasticity. It is because at this high shipbuilding price level, only those very few shipowners with very profitable trading opportunities will order new ships. At the lower end of shipbuilding prices, orders will be limited due to lack of trading opportunities, financial limitations and longer delivery times from the ship yards. However, the demand and supply proposition is not practically useful. Firstly it gives a very static picture of the shipbuilding market and is of limited value for a dynamic analysis of the shipbuilding market. Secondly, shipyard capacity as the supply variable was proven to be a very difficult one to find data for. In the absence of shipyard capacity data, the demand and supply proposition cannot be applied in practice.

In the cost-based proposition, the shipbuilding cost is the most influential factor in determining the shipbuilding price. However, subsidies are commonly applied in the shipbuilding industry. The efficiency varies across yards. As a result, the shipbuilding cost is not a reliable indicator for the fluctuation in shipbuilding price.

The asset pricing proposition has been adopted in most studies, e.g. Beenstock and Vergottis (1989). Under this asset pricing proposition, newly built ships and second-hand ships are perfect substitutes with shipbuilding discounted time value; the shipbuilding prices co-move with second-hand ship prices over time.

Many studies discussed shipping economics and focused on freight market exclusively. Shipbuilding was only involved in these studies as related variables. Table 2-1 summarised the studies on shipbuilding market from economic perspective. Two variables about shipbuilding market have been discussed most: orders for new ships and ship prices. Other related variables include ship investment, fleet size, demand for vessels and shipbuilding delivery.

Hawdon (1978) wrote one of the first few papers on modelling the freight rate. He studied the determination of tanker freight rates in the short and long run. In the long run, he mentioned the shipbuilding market's influence to the gross investment decisions of the shipowners, such as shipbuilding price, the size of the fleet and overall size of the ship ordered. He modelled orders for new tankers and ship prices for tanker shipbuilding market. Orders of new tankers is regressed against price of new tankers, world international seaborne trade in oil and tanker voyage freight index; while Ship prices are regressed on tanker voyage freight index, world tanker fleet, past price of new tankers and average size of tankers in the world fleet.

Charemza and Gronicki (1981) provided aggregated long-run models for world shipping and world shipbuilding. In the world shipbuilding segment, the models include demand for shipbuilding orders, supply of shipbuilding orders and ship prices. Demand for shipbuilding orders is affected by the fleet existing at the beginning of the period, tanker freight rate and oil shipment volume. Ship prices depend on previous ship price, tanker freight rate and oil shipment volume.

Nielsen, Kristensen, Bastiansen and Skytte (1982) performed macro forecasts of demand for and supply of transportation in the maritime sector. The authors presented a causal loop diagram of the dynamic development of contracting and deliveries. The lead time from contracting of new ships to the time of delivery is approximately 2 years. This long production time makes the system unstable because the contractings respond very quickly to marginal changes in the freight rates. The authors also mentioned that if the requirement for DWT is greater than the supply, it results in expansion of the orderbook by contracting, and a period with high contracting followed by low growth economy will for a long time result in surplus tonnage.

Beenstock and Vergottis (1989) for the first time investigated the freight and ship markets in an interdependent setting in which freight market developments depend on the markets for ships and vice versa. The size of the fleet affects freight rates while freight rates affect the stock demand for vessels. Freight rate, shipbuilding prices and fleet size are dynamically interdependent. The models are based on efficient markets/rational expectations hypotheses. In the shipbuilding sector, deliveries of new ships depend on past values of deliveries and orderbook; the size of the dry cargo orderbook is related to past values of shipbuilding orders, deliveries of new dry cargo vessels and shipbuilding prices; shipbuilding prices are an index of expected future second-hand ship prices.

Marlow (1991) wrote a trilogy about investment incentives and shipping industry, and in the third paper specifically discussed the major determinants of investment in the UK shipping industry. Ship investment is functioned by a series of variables: capacity utilisation (percentage of active fleet in total world fleet); total world fleet; demand for shipping (world seaborne trade); investment incentives; credit arrangement and expectations of the shipowners.

Dikos (2004) drew the conclusion that the pricing by shipyards is determined only in terms of production costs and market share conditions, not the ordered deadweight in each period. New vessel prices seem to be sub-optimal and inelastic with respect to the demand for new vessels. The dependence of costs on the demand for new vessels is relatively weak.

Mulligan (2008) presented new models for estimating shipbuilding costs from the ship design and construction perspectives. Shipbuilding costs are modelled as a first-order function of PPI (producer price index) and a third-order function of deadweight function for various types and standard ship sizes.

Engelen, Meersman and Van de Voorde (2006) used system dynamics approach to model the different shipping markets. In the new-building market part, order rate, delivery time and shipbuilding price are modelled. The ordering behaviour is claimed to depend on the level of rates, since the earning potential of a ship (freight rate) over its lifetime is considered as the price of the ship. The shipbuilding price is determined by the long-term equilibrium freight rate. The authors also mentioned that the time lag between the ordering and delivery of the vessel explains part of the structural inequality in shipping, this delay triggers additional dynamic behaviour within the system.

Bessler, Drobetz and Seidel (2008) did an empirical analysis of the relationship between spot and forward prices in freight markets. They studied the dynamics of spot and forward freight rates, such as cointegration and equilibrium, from a ship investment perspective. Their findings suggest that time series properties of freight rates need to be well understood before investing in ship funds.

Lun and Quaddus (2009) developed an empirical shipping market model to predict fleet size. Their study incorporated the key variables in four shipping markets: shipbuilding, second-hand and scrap vessel prices, freight rate, fleet size, and seaborne trade. Seaborne trade and freight rate are proved to be positively related to fleet size. Freight rate has a significant impact on shipbuilding, second-hand and scrap vessel prices.

From the above studies, we can observe that orders for new ships is commonly regressed on the following variables: 1. demand for shipping service, which is often represented by world seaborne trade, 2. supply of shipping service, such as total world fleet, existing orderbook, deliveries of new vessels; 3. freight rate level, and 4. several other prices, such as shipbuilding prices and second hand ship prices. Another frequently studied variable ship prices is commonly regressed on previous ship prices, freight rate, fleet size, second hand ship prices and production cost.

Table 2-1 Summary of studies on shipbuilding market from economic perspective

Authors	***Journal***	***Variables for shipbuilding market***
Hawdon (1978)	Applied Economics	Orders for new tankers, ship price
Charemza and Gronicki (1981)	Maritime Policy & Management	Shipbuilding orders, ship price
Nielsen, Kristensen, Bastiansen and Skytte (1982)	Long Range Planning	Orderbook, fleet size
Beenstock and Vergottis (1989)	Applied Economics	Fleet size, demand for vessels, shipbuilding delivery, orderbook, shipbuilding price
Marlow (1991)	Maritime Policy & Management	Ship investment
Dikos (2004)	Maritime Economics & Logistics	Ship price
Mulligan (2008)	Maritime Economics & Logistics	Ship price
Engelen, Meersman and Van de Voorde (2006)	Maritime Policy & Management	Ship orders, shipbuilding price
Bessler, Drobetz and Seidel (2008)	Journal of Asset Mangement	Ship investment, fleet size
Lun and Quaddus (2009)	International Journal of Shipping and Transport Logistics	Shipbuilding price

2.2.2 The pricing of ships: second hand ship price and scrapping price

The pricing of ships has been studied as a capital asset with the asset pricing determined by measuring the net present value of expected earning potential (for example, Dikos, 2004; Alizadeh and Nomikos, 2007). Besides shipbuilding prices, Second hand ship price and Scrapping price have also been studied in previous research.

Dikos and Marcus (2003) applied structural partial equilibrium model to explain the prices of second-hand vessels by the prices of new vessels and the charter rates. Alizadeh and Nomikos (2007) investigated the long-run cointegration relationship between price and earning of investing second-hand market for ships through cointegration VECM. The analysis part focused on investment timing and strategies.

Knapp, Kumar and Remijn (2008) studied the dynamics of the ship recycling market using econometric modelling. The variables include scrap price and basic ship information, such as ship type, tonnage and ownership.

2.3 Policy Related Research

There are two types of studies on shipbuilding policy: first, the effect of public policy on shipbuilding investment, and second, a country's policy towards its shipbuilding industry.

Shipbuilding is a very attractive industry for a country as it can bring a substantial amount of foreign direct investment. There has been a handful of research on the effect of fiscal policy and investment incentives on shipbuilding investment. Marlow (1991) mentioned that during the mid-1960s it was less common than before for shipowners to finance investment from their own funds. Since then the governmental investment schemes on shipping industry have become so favourable that the real rate of interest has been negative in some cases. Shipowners would naturally tend to obtain investment funds from other sources instead of their own funds, among which one of the most popular nowadays is foreign direct investment (FDI). There have been a handful of studies on the impact of FDI on the maritime industry. Kind and Strandenes (2002) used Singapore as an example to analyse the host country effects of FDI. They argued that the main reason why Norwegian maritime industry considers investing in Asia is the public policy there, which was formed to consciously encourage FDI in export oriented manufacturing and services, and host clusters seem to be more important for service providers in transport or repair and maintenance markets than for industrial manufacturers.

Akselsen (2000), Tenold (2000), and Kind and Strandenes (2002) all discussed the location advantage to the shipping investment in their study of FDI and maritime industry. The location advantage of the maritime cluster to the different home countries also differs, for example, the tax heaven, low transaction costs, low barriers to trade, and closer to customer market.

Zeien (1991) wrote a monograph to discuss different types of shipyard subsidies and their effects on shipbuilding industry in the United States. The author drew the conclusion that to eliminate subsidies is beneficial to the world-wide shipbuilding market. He also discussed the United States' role to create a level playing field for the world shipping industry.

In respect to a country's shipbuilding policy, here we list three papers discussing the shipbuilding policy in China, Korea and around the world. Song (1990) discussed the shipping and shipbuilding policies in China. The author mentioned that the two industries were under greatest development ever and becoming increasingly important to China’s national economy. Lee (1990) discussed the role of the Korean government in Korean shipping: the government plays both direct and indirect roles in Korean shipping growth. The paper also concluded that the expansion of shipping in Korea was a response to the export-oriented industrialization policy. King (1999) discussed the new directions in shipbuilding policy around the world in the 1990s. He mentioned shipbuilding policy in Europe is very different from other shipbuilding states, such as Japan, South Korea and China. While shipbuilding in Europe has been more or less accepted by the industry and academics as ‘an out-dated and poorly managed’ industry, in Japan, and later in South Korea and China, shipbuilding industry has been identified as a key and strategic industry which has gained enormous government support and enjoys specially created green field sites with state protection.

2.4 Strategy Related Research

We categorise the studies on shipbuilding behaviour, such as investment timing and tonnage, into strategy related research. These papers use dynamic simulation to model the cycle of the market and shipbuilding process to help improve the ship investment decision in the cyclical shipping market.

Koskinen and Hilmola (2005) used system dynamics simulation to model investment cycles in the shipbuilding market of ice-strengthened oil tankers. The variables in the simulation models include future transport demand, terminal capacity and shipbuilding tonnages.

Bendall and Stent (2005) applied real option approach to simulate ship investment under uncertainty. They proved that real option approach is a useful tool to value the flexibility of ship management to adapt a project in conditions of uncertainty.

Dikos et al. (2006) developed and implemented system dynamics models to help managers improve their investment decisions in the cyclical tanker market. The results revealed the key factors that affect taker rates and unforeseen dynamics.

Audia and Greve (2006) used data in shipbuilding firms to analyse how firm size and firm performance affect risk taking decision in shipbuilding industry. They applied Generalized Estimating Equations (GEE) models.

2.5 Technology Related Research

There have been plenty of studies on the technological part of shipbuilding, such as ship design and shipbuilding innovation. Here two papers are quoted to illustrate the large amount of papers on shipbuilding technology. Motora (1997) discussed 100 years of history of Japan's shipbuilding industry from the technological perspectives. Pires Jr., Lamb and Souza (2009) applied Data Envelopment Analysis (DEA) and Analytic Hierarchy Process (AHP) methods to assess shipyard performance. They suggested a methodology for shipbuilding performance assessment.

2.6 New Economic Perspectives and Issues in Shipbuilding

2.6.1 Dynamics between shipbuilding market and other shipping markets

Many existing studies have focused on the characteristics of shipping freight rate and looked at factors influencing these rates (Hawdon, 1978; Beenstock and Vergottis, 1993). Beenstock and Vergottis (1989) concluded a regression analysis of shipping market and found that shipbuilding price responds very little against the freight rate and no time delay is observed across shipping markets. New studies are needed to examine and clarify the dynamic relationships between freight rate and shipbuilding price. Thus, rather than building a regression model for freight rate or shipbuilding price (e.g. Dikos, 2004; Mulligan 2008), we raise our research question 1 to analyse the directional relationship between freight market and shipbuilding market, we also include other shipping markets, such as second hand market and demolition market in this discussion.

2.6.2 Determinants of shipbuilding activities

Previous studies on shipbuilding have been mainly about modelling the shipbuilding prices, or involving shipbuilding as related variables when discussing other shipping markets. They assumed that the newly built ships and second-hand ships are perfect substitutes and their prices are linked according to the net present value. However, few of them analysed how and why the amount of shipbuilding orders fluctuates over time. The few papers on ship investment behaviour discussed it from individual countries' cases (Marlow, 1991; Kind and Strandenes, 2002). Therefore, the research question 2 deals with the determinants of shipbuilding activities. This research question will be studied through panel data analysis, which aggregates all the individuals and allows us to model differences in behaviour across individuals over time.

2.6.3 Dynamics between fleet size and freight volatility

In other markets, such as stock market, the positive relationship between stock price volatility and trading volume has been widely confirmed (see, for example, Gallant, Rossi and Tauchen, 1992; Jones, Kaul and Lipson, 1994). In shipping economics studies however, few have discussed the relationship between fleet size and freight rate volatility, while an abundance of research has been done to understand the time-varying characteristics of freight rate volatility (Kavussanos, 1996; Kavussanos, 2003; Lu, Marlow and Wang, 2008; among others). It is widely acknowledged of the highly volatile nature of the freight rate, however, the impacts and the causes of the time-varying risk in shipping markets has been left unstudied. Of all the variables that might cause the high volatility of freight rate, fleet size is believed to be the one that changes most severely along the time, due to the habitual massive shipbuilding orders in shipbuilding market and the lag between the shipbuilding order and delivery. Therefore, we raise our research question 3 concerning the impact of the change of fleet size on freight volatility.

2.7 Summary

In this chapter, we review the literature relevant to shipbuilding from four perspectives: economics, policy, strategy and technology. We specifically list the studies related to shipbuilding from economic perspective. It is well noticed that shipbuilding has been scarcely studied from the viewpoint of economics. We can find only a handful of studies discussing exclusively about shipbuilding economics, most studies only involve shipbuilding as related variables when discussing other shipping markets. Based on the current literature, we develop three research questions in corresponding to the research questions we have put forward.

3 METHODOLOGY

In this chapter, we discuss the methodology adopted in this study. The methodology trend in shipping economics research has been shifted from structural modelling to more advanced econometric tools. We also introduce the analytical techniques adopted in this thesis.

3.1 Structural Modelling

As discussed in previous chapters, most of the earlier economic studies on shipping focus on structural modelling for estimating purpose (Hawdon, 1978; Charemza and Gronicki, 1981; Beenstock and Vergottis, 1989). They assumed that the shipping prices react to market information simultaneously, and did not fully consider its time-varying nature. One of the examples is Beenstock and Vergottis (1993)'s book *Econometric Modelling of World Shipping*, in which they developed complex econometric models for ship prices relating freight market, second hand markets, shipbuilding market and scrap market. Beenstock and Vergottis (1993) fully included structural econometric models for bulk shipping market based on market efficiency theory.

Structural modelling often suffers from statistical shortcomings such as autocorrelation, multi-collinearity and heteroscedasticity that make their estimates biased, since shipping related time series have been shown to exhibit time-varying characteristics (see, for example, Kavussanos, 1996 and 2003; Adland and Cullinane, 2005; Lu, Marlow and Wang, 2008). More advanced econometric techniques, such as cointegration test, error correction model (ECM) and autoregressive conditional heteroskedasticity (ARCH) model, have been adopted to analyse the shipping markets. We briefly introduce the econometric techniques adopted in this thesis. We mainly refer to the following three Econometric books in this thesis: Greene, 2008; Hamilton, 1994 and Hayashi, 2000.

3.2 Time Series Techniques

Time series models have been gradually developed in shipping economics to overcome the shortcomings of structural models (Kavussanos, 1996; Veenstra, 1999). Time series analysis accounts for the fact that data points taken over time may have an internal structure (such as autocorrelation, trend or seasonal variation) that should be accounted for. Greene (2008) mentioned that the large simultaneous-equations macroeconomic models frequently have poorer forecasting performance than fairly simple, univariate time-series models based only on just a few parameters and compact specifications. Time series analysis comprises methods for analysing time series data in order to extract meaningful statistics and other characteristics of the data.

Time series models can be divided into stationary time series models and non-stationary time series models (Hamilton, 1994). In this thesis, we adopt non-stationary time series techniques, as shipping related time series have been proved to exhibit time-varying characteristics (Kavussanos, 1996; Kavussanos, 2003; Lu, Marlow and Wang, 2008; among others).

3.2.1 Unit root test

Unit root test is performed to check whether the time series are stationary or not. Unit root process is a type of widely-seen time series in economics and finance, and possibly in other fields as well. The behaviours and properties of stationary and non-stationary time series differ substantially (Hayashi, 2000). The traditional inferences for stationary series could be wrong to the non-stationary processes; this is why we need to study the unit-root processes. It is a necessary first step before assessing the long-run equilibrium relationship among the variables. In most of the cases, a time series variable has one unit root, denoted as *I(1)*. It means that the time series is non-stationary but the first order difference of it is stationary. Two commonly-used methods are adopted for the unit root tests: Augmented Dickey-Fuller (ADF) test (*Dickey and Fuller, 1979*) and Phillips and Perron (PP) test (*Phillips and Perron, 1988*).

The simplest version of the Dickey-Fuller (DF) tests is to consider a simple *AR(1)* model:

$$y_t = \rho y_{t-1} + u_t, \tag{3-1}$$

where y_t is a time-series variable, *t* indexes time, ρ is the coefficient of the first-order lag of the time series, and u_t is the error term, a white noise process. A unit root is present if ρ = 1, which means that the time series y_t follows a random walk. The null hypothesis of the test is ρ = 1. The DF test is used as under the null hypothesis: the conventional t-statistic does not follow a t-distribution.

In recent years, *Hardi* (2000), *Breitung* (2000), *Levin, Lin & Chu* (2002), and *Im, Pesaran & Shin* (2003) developed panel unit root tests. They showed that panel unit root tests are more powerful (or less likely to commit a Type II error) than traditional unit root tests applicable to a single time series. It is especially important when the time-series sample size is small.

To determine the lag lengths, the Schwarz Information Criterion (SIC) is used in this study. It is a criterion for model selection among a class of parametric models with different numbers of parameters (Schwarz, 1978).

3.2.2 Cointegration test

A linear combination of non-stationary time series tends to exhibit stationary characteristics, it shows many time series are non-stationary but 'move' together. Cointegration test is conducted to determine the existence of such long-term relationships among time series. Based on the results of unit root tests, the *I(1)* time series may be considered as candidates for possible cointegrating relationship (*McAleer and Oxley, 1999*). The cointegration captures a tendency for some linear relationships among non-stationary variables over a long period of time. A linear combination of the two non-stationary time series with lag length is stationary means that a long-run equilibrium relationship exists between the original two series.

Johansen (1988) and *Johansen and Juselius (1990)* proposed a vector autoregression (VAR)-based cointegration test. It is a system-based reduced-rank approach used to test long-run equilibrium relationships among the variables.

Consider a vector autoregressive (VAR) model of order p:

$$y_t = A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t, \tag{3-2}$$

where y_t is a k-vector of non-stationary, $I(1)$ variables, x_t is a d-vector of deterministic variables, and ε_t is the error term. We can rewrite the VAR as:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t, \tag{3-3}$$

where $\prod = \sum_{i=1}^{p} A_i - I$, $\Gamma_i = -\sum_{j=i+1}^{p} A_j$. (3-4)

The reduced rank r is known as the number of cointegrating relations (the cointegrating rank). If $k = 2$, then the maximum number of cointegrating relations is one, which is the simplest case for cointegration tests.

The estimated trace statistic λ_{trace} and maximum eigenvalue statistics $\lambda_{\max}$ are used to determine the number of cointegrting vectors, which implies the long-run relationship among variables, the more cointegrating vectors the model has, the more stable the system composed of non-stationary variables will be.

3.2.3 Granger causality test

Granger causality test is conducted to determine the cause-effect relationship with variables. If two variables are cointegrated then causality must exist in at least one direction (*Granger, 1986*). Granger causality is to check whether one time series is useful in forecasting the other.

Engle and Granger (1987) pointed out, if the variables are cointegrated, a pure VAR model in difference to test the existence of Granger causality will be miss-specified. Vector error correction model (VECM) (*Johansen, 1988*) is suggested to estimate cointegrated data. We adopt VECM in this thesis to test the Granger causality:

$$\Delta y_t = \prod y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t , \tag{3-5}$$

where y_t is the column vector of two variables (time series X and Y), each being non-stationary, $I(1)$ variables, Δ denotes the first difference operator, $\prod$ and Γ_i are used to test the long-run and short-run adjustment to changes in y_t. The causal relationship of the variables is evaluated by the expanded VECM. The test works by first doing a regression of ΔX (or ΔY) on lagged values of ΔX (or ΔY). Once the appropriate lag interval for X (or Y) is proved significant (through t-statistic or p-value), subsequent regressions for lagged levels of ΔY(or ΔX) are performed and added to the regression provided it is statistically significant and provides explanatory power. The joint significance of the lagged estimated coefficients can be tested by F-tests; the significance of the error correction coefficients can be tested by t-tests.

3.2.4 Impulse response analysis

Impulse response analysis acts as one step further to Granger causality test, which provides a more detailed insight on causal relationship by indicating whether the impacts are positive or negative, and whether such impacts are temporary or long-termed.

Impulse response analysis traces the effect of a one standard deviation shock to one of the innovation on current and future values of the endogenous variables. Impulse response analysis shows how the variables in the VECM system respond to a standard exogenous change of another variable. A shock to the i-th variable directly affects the i-th variable itself, and is also transmitted to all of the endogenous variables through the dynamic structure of the VECM. Sims (1980)'s original approach depends on the ordering of the variables in a system (Lutkepohl, 1991). Pesaran and Shin (1998) suggested the use of Generalized Impulse Responses by constructing an orthogonal set of innovations which resolved the problem of depending on the ordering of the variables in the system. In this thesis, Generalized impulse response analysis is employed.

3.2.5 ARCH type models

The Autoregressive Conditional Heteroskedasticity (ARCH) and Generalised Autoregressive Conditional Heteroskedasticity (GARCH) models are employed commonly in modelling volatility of financial time series that exhibit time-varying volatility clustering, namely, periods of swings followed by periods of relative calm.

The ARCH model was introduced by Engle (1982) to model the volatility of UK inflation. Since then this methodology has been employed to capture the empirical regularity of non-constant variances, such as stock return data, interest rates and foreign exchange rates (Bollerslev and Melvin, 1994, among others). An abundance of research in shipping has adopted ARCH model to understand the time-varying characteristics of freight rate volatility (Kavussanos, 1996; Kavussanos, 2003; Lu, Marlow and Wang, 2008; among others).

ARCH model considers the variance of the current error term to be a function of the variances of the previous time period's error terms. ARCH relates the error variance to the square of a previous period's error. As the name suggests, the model has the following properties: (1) Autoregression - Uses previous estimates of volatility to calculate subsequent (future) values. Hence volatility values are closely related. (2) Heteroskedasticity - The probability distributions of the volatility varies with the current value. It has been proved that a GARCH model adequately fits many economic time-series (Bollerslev, 1987).

$$r_t = b_0 + b_1 r_{t-1} + b_2 r_{t-2} + \cdots + b_m r_{t-m} + \varepsilon_t, \qquad \varepsilon_t \sim iid(0, h_t) \tag{3-6}$$

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \tag{3-7}$$

where r_t is the time series variable, ε_t is the error term that follows a normal distribution with mean zero and time-varying variance h_t, iid stands for independent and identically-distributed.

3.3 GMM estimation

To model time series variables with Ordinary Least Square (OLS) or Generalised Least Squares (GLS) model, we often lead to inconsistent estimation. The coefficient value or significant level may be seriously upward biased due to failures of some assumptions, such as collinearity, autocorrelation, and heteroscedasticity, which imply inefficient standard errors.

Generalized method of moments (GMM) estimation is very often used on time series models. GMM is a very general statistical method for obtaining estimates of parameters of statistical models. In the twenty years since it was first introduced by Hansen (1982) of the method of moments, GMM has become a very popular tool among empirical researchers. It is also a very useful heuristic tool. Many standard estimators, including instrument variable (IV) and ordinary least squares (OLS), can be seen as special cases of GMM estimators.

GMM is a good estimator to deal with autocorrelation and heterogeneity issues. The GMM approach allows an instrument to be used, thereby avoiding any simultaneity bias. The GMM brings the advantage of consistent estimation in the presence of heteroscedasticity and autocorrelation (Newey and West, 1987). Baum et al. (2003) also mentioned that GMM makes use of the orthogonality conditions to allow for efficient estimation in the presence of heteroskedasticity of unknown form.

3.4 Panel data analysis

Time series and cross-sectional data are special cases of panel data that are in one-dimension only. The fundamental advantage of using panel data set over a cross section is that it allows great flexibility in modelling differences in behavior across individuals over time (Greene, 2008). The basic model for panel data is:

$$y_{it} = x'_{it}\beta + z'_i\alpha + \varepsilon_{it} \tag{3-8}$$

where x_{it} represents the regressors, $z'_i\alpha$ represents the heterogeneity, or individual effect, where z_i contains a constant term and/or a set of individual or group specific variables. There are several types of panel data analytic models, such as constant coefficients models, fixed effects models, and random effects models (Greene, 2008). We first need to consider the regression model.

One type of panel models has constant coefficients, referring to both intercepts and slopes. When there is neither significant country nor significant temporal effects, we can pool all of the data and run an ordinary least squares regression model. Although most of the time there are either country or temporal effects, there are occasions when neither of these is statistically significant. This model is called the pooled regression model. We apply *F* test on the change of the *R* squared value between the fixed effects model and the pooled regression model.

3.5 Summary

In this chapter, we discuss the methodology trend in shipping economics research. Research methodology has been shifted from structural modelling to more advanced econometric tools. We also introduce the analytical techniques adopted in this study. Dynamics between shipbuilding market and other markets and the possible impact brought by what happens in shipbuilding market are left unexamined in the literature, we adopt a series of time-series and panel techniques in this thesis to analyse shipbuilding market in a wide context.

4 FREIGHT AND SHIPBUILDING MARKETS

4.1 Introduction

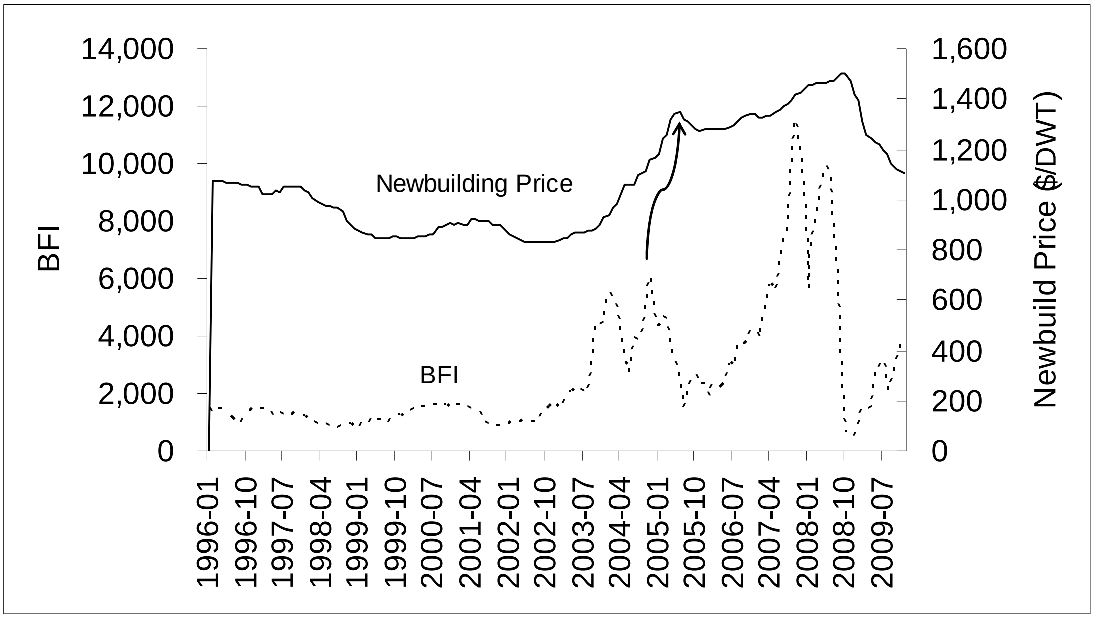
This chapter studies the dynamic relationship between shipbuilding price and sea freight rate in the shipping industry. This directional relationship has not received sufficient attention in the maritime economics literature yet. In an equilibrium framework, freight rates in the sea transport market are determined by the interactions of supply and demand for cargo carrying services while the shipbuilding price depends on the supply and demand of shipbuilding capacities. The effects of ship size and contract duration on this lead-lag relationship have not been investigated in the literature, although insights into this dynamic relationship could provide vital implications for shipbuilding strategies and policies.

A shipowner often faces difficult decisions on the timing of shipbuilding. Since a ship needs to be designed, constructed and commissioned long before coming into service, a new ship is usually delivered into the freight market 18 months to 2 years after the initial decision. Market conditions can be totally different after such a long delay. Consequently, shipbuilding decisions are inherently risky and wrong timing can turn a handsome expected profit into heavy losses.

Based on the cyclical nature of the shipping markets, we have good reasons to assume that the freight market could provide a good signal and guide to shipowners during their strategic decision-making of building new ships. Shipbuilding demand is a derived demand, as it depends mainly on the operating environment of the shipping market. While one can imagine the existence of a relationship between shipbuilding price and freight rate, the direction of causality between them is not known.

Shipbuilding is commonly considered exogenous of freight markets, because its long cycle introduces long delays in the supply side. In the existing literature freight rate is determined by the demand for trade, the supply of ships and other macro-economic factors of the sea freight market (for example, *Evans and Marlow, 1990*). For example, Beenstock and Vergottis (1993) developed a complete model of freight rate relations and an integrated model of shipping markets. Assuming the efficient market hypothesis, they found the shipbuilding market resembles a forward market of ships in its models. Through simulation they discovered that an increase in freight rate results in a small response in shipbuilding price and there is an absence of lags among prices. However, this conclusion cannot be verified by observable market data. Historically, as shown in Figure 4-1, an arrow shows that shipbuilding prices peaked about several months after that of freight rates, in other words, the shipbuilding cycle usually follows that of shipping with a lag. Stopford (2009) explained the cycle of the freight market. Shipowners earn cash in the freight market and will order new ships due to their confidence on the future freight market. From the point of view of shipowners, we postulate our a priori hypothesis: Freight rate leads shipbuilding price.

Figure 4-1 Capesize bulker newbuild prices vs. Baltic Freight Index



Source: Clarkson’s Shipping Intelligence Network

Ships are categorised according to three major cargo types: dry bulk cargo, tanker (liquid bulk) cargo, and container cargo. The dry bulk shipping market is considered close to perfect competition because this market is believed to consist of a multitude of small players, shipowners or charterers, and the market rate is set by the aggregate action of all market participates and free from government intervention. Shipowners and charterers are too numerous and relatively small to influence the market price (that is, freight rates) substantially. Therefore, we study the market-driven dynamic relationship between freight rate and shipbuilding price in the dry-bulk shipping sector.

Following in this chapter, in 4.2, the related literature in the shipping markets and theoretical considerations are reviewed. In 4.3 and 4.4, the research framework and data are discussed. In 4.5, we provide the empirical results and implications. Finally in 4.6, we summarise the findings and outlines future areas of study.

4.2 Literature Review

In this chapter, we attempt to examine the interdependence of freight and shipbuilding markets, where the sea freight market trades sea transport service and the shipbuilding market trades new ships. Two areas of the literature are pertinent to this chapter: the research on shipping freight rate and shipbuilding price, and the dynamic relationship between the two markets.

Freight rates have been considered the most critical indicators for shipping markets because they represent the principal source of earnings for the shipping industry. Many existing studies have focused on the characteristics of shipping freight rate, for example, the determinants (*Hawdon, 1978; Beenstock and Vergottis, 1993*), stationarity

(Koekebakker, Adland and Sodal, 2006), cointegration (*De Borger and Nonneman, 1981*) and term structures (*Kavussanos, 1996; Veenstra, 1999*).

These studies showed that the freight rate is not stationary like most economic and financial time series (see *Kavussanos and Visbikis 2006*, *Alizadeh and Nomikos 2009*) and that the freight rate is determined by the demand for trade, the supply of ships and other macro-economic factors of the sea freight market (for example, *Hsu and Goodwin, 1995; Evans and Marlow, 1990*). Existing studies on shipping market focus on freight market models, and few of them look into the interactions between shipbuilding markets and freight markets. *Beenstock and Vergottis (1989)* concluded a regression analysis of shipping market and found that shipbuilding price responds very little against the freight rate and no time delay is observed across shipping markets. These two findings are different from our observations, and new studies are needed to examine and clarify the dynamic relationships between freight rate and shipbuilding price.

The pricing of ships has been studied as a capital asset with the asset pricing determined by measuring the net present value of expected earning potential (for example, *Dikos, 2004; Alizadeh and Nomikos, 2007*). The existing literature contributes to the forecasting of ship prices but the directional relationship between the shipbuilding price and freight rate is left unexamined. Thus, rather than building a regression model (e.g. *Dikos, 2004*; *Mulligan 2008*), we investigate the directional causality relationship.

Directional causality relationships between freight markets have been studied, such as spot versus period, spot versus futures (*Kavussanos and Nomikos, 2003; Kavussanos and Visvikis, 2004; Batchelor, Alizadeh and Visvikis 2005; Glen 2006*). The lead-lag relationship between two markets indicates how fast one market reflects information relative to the other and how well the two markets are linked. An abundance of empirical works have analyzed the lead-lag relationship in the financial economics literature, for example, *Bollerslev and Melvin (1994)* and *Tse and Booth (1995)* in foreign exchange.

Based on the economic production function, ships (capital goods) are used to provide freight services (production) and the freight rate should depend on shipbuilding price. This idea is incorporated in the previously mentioned regression studies (for example, *Beenstock and Vergottis 1989*). Meanwhile, from the point of view of shipowners' cash-flow, Stopford (2009) explained the cycle of the freight market. He described how shipowners who have earned cash in the freight market will order new ships due to their confidence on the future freight market. We examine these two competing views by determining how freight rates and shipbuilding prices are related.

In order to explore the existence of directional relationships between freight rate and shipbuilding price, reduced form models of freight rate and shipbuilding price will be used. We will provide conclusive evidence of the validity of the freight-leading shipbuilding hypothesis. A cointegration relationship, that is, a long-run equilibrium relationship among the variables in the regression equation, is found by heterogeneous panel cointegration test. Such panel tests have been used predominately in testing the purchasing power parity (PPP).

4.3 Research Framework and Methodology

To determine the interrelationships between shipbuilding price and freight rate, a three-stage approach is taken with each step being a prerequisite of its next step. Firstly, the unit root test is performed to check whether the freight rate and shipbuilding price time series are stationary or not. Secondly, the test for cointegration is conducted to determine the existence of long-term relationships between the two time series. Thirdly, the Granger causality test is conducted to determine the cause-effect relationship with variables. Impulse response analysis acts as one step further to Granger causality test, which provides a more detailed insight on causal relationship by indicating whether the impacts are positive or negative, and whether such impacts are temporary or long-termed.

In order to explore the existence of directional relationships between freight rate and shipbuilding price, a reduced form of vector error correction model (VECM) (*Johansen, 1988*) is applied:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t , \tag{4-1}$$

where $y_t = (SBP_t \;\; FRT_t)'$ is the column vector of logarithm shipbuilding price and freight rate.

It is worth to notice, the first two steps, unit root test and cointegration test, are applies in a panel time series manner. The panel time series technique has not been applied to the study of shipping markets so far. In recent years, *Hardi* (2000), *Breitung* (2000), *Levin, Lin & Chu* (2002), and *Im, Pesaran & Shin* (2003) developed panel unit root tests. They showed that panel unit root tests are more powerful (or less likely to commit a Type II error) than traditional unit root tests applicable to a single time series. It is especially important when the time-series sample size is small. Because shipping data size is commonly small, the analysis based on uni-variate time series technique is less reliable. Such panel tests have been used predominately in testing the purchasing power parity (*PPP*). Surveys on testing unit roots and cointegration in panels have been done by *Breitung and Pesaran* (2008) and *Baltagi* (2008, Ch. 12).

4.4 Data Description

The time series data used covers the shipbuilding price and freight rate over the period 1998 to 2009, depending on availability (source: Clarkson 2009). The time series of shipbuilding price (*SBP*) are monthly data in US dollars per compensated gross ton. The freight rate (*FRT*) time series are quoted in 3 different terms:

- Baltic dry indices (*BDI*) for spot-term contract,
- One-year time charter rate (*TC1*) for one-year term contract, and
- Three-year time charter rate (*TC3*) for three-year term contract.

SBP and *FRT* are further categorised into three different ship sizes: Capesize vessels (120,000 deadweight tons) transport iron ore and coal. Panamax vessels (70,000 deadweight tons) are used primarily to carry grains. Handymax vessels (10,000 deadweight tons) transport minor bulk products. The subscripts *C*, *P* and *H* denote capesize, panamax and handymax ship sizes, respectively. The source and description of the variables are listed in Table 4-1. A remark on the recent conversion of *BDI* from handymax to supramax is reviewed in Appendix 4A.

Table 4-1 List of variables

Variable	***Source***	***Description***
BDI_C	SIN data	Baltic dry indices: Capesize vessels
$TC1_C$	SIN data	One-year time charter rate: Capesize vessels (US dollars per day)
$TC3_C$	SIN data	Three-year time charter rate: Capesize vessels (US dollars per day)
SBP_C	SIN data	Shipbuilding price: Capesize vessels (US dollars per compensated gross ton)
BDI_P	SIN data	Baltic dry indices: Panamax vessels
$TC1_P$	SIN data	One-year time charter rate: Panamax vessels (US dollars per day)
$TC3_P$	SIN data	Three-year time charter rate: Panamax vessels (US dollars per day)
SBP_P	SIN data	Shipbuilding price: Panamax vessels (US dollars per compensated gross ton)
BDI_H	SIN data	Baltic dry indices: Handymax vessels
$TC1_H$	SIN data	One-year time charter rate: Handymax vessels (US dollars per day)
$TC3_H$	SIN data	Three-year time charter rate: Handymax vessels (US dollars per day)
SBP_H	SIN data	Shipbuilding price: Handymax vessels (US dollars per compensated gross ton)

Summary descriptive statistics of monthly freight rates and shipbuilding prices in logarithms for three sizes of dry bulk ships are shown in Table 4-2. All the time series data are transformed into natural logarithms.

Table 4-2 Descriptive statistics of Capesize, Panamax and Handymax ships

	N	***Mean***	***Std.Dev.***	***Skewness***	***Kurtosis***	***J-B***	***Probability***

Capesize Bulker series (1999:03-2009:05)							
BDI_C	123	8.084	0.794	0.186	2.093	4.922	0.085
$TC1_C$	123	10.239	0.787	0.414	2.041	8.222	0.016
$TC3_C$	123	10.068	0.647	0.708	2.450	11.821	0.003
SBP_C	123	7.539	0.359	0.306	1.689	10.728	0.005
Panamax Bulker series (1998:05-2009:05)							
BDI_P	133	7.693	0.740	0.378	2.108	7.584	0.023
$TC1_P$	133	9.477	0.709	0.874	2.757	17.245	0.000
$TC3_P$	133	9.275	0.532	1.372	3.934	46.546	0.000
SBP_P	133	7.356	0.339	0.419	1.757	12.453	0.002
Handymax Bulker series (2000:09-2009:05)							
BDI_H	105	9.753	0.666	-0.028	2.034	4.098	0.129
$TC1_H$	105	9.632	0.714	0.625	2.352	8.675	0.013
$TC3_H$	105	9.366	0.561	1.080	3.111	20.473	0.000
SBP_H	105	7.590	0.329	0.139	1.653	8.270	0.016

Note:

- All series are measured in logarithms.
- BDI, TC1 and TC3 denote the freight rate for spot-term, 1-year term and 3-year term contracts
- SBP denotes the shipbuilding price.
- N is the number of observations.
- J-B is the Jarque-Bera statistic for testing whether the series is normally distributed.
- Probability is the probability that a Jarque-Bera statistic exceeds (in absolute value) the observed value under the null hypothesis. A small probability value leads to the rejection of the null hypothesis of a normal distribution.

The mean values of spot freight rate (Baltic Dry Indices) for smaller vessels are higher than for larger ones. In contrast, time-charter rates are higher for the larger vessels than smaller ones. The standard derivations of freight rates and shipbuilding price seem to be higher for larger vessels than for smaller ones. The fluctuation of freight rates declines as the contract duration increases, but the freight rates tend to be more volatile than the shipbuilding price in terms of standard deviations.

Positive coefficients of kurtosis indicate the leptokurtic property of all time series. Positive coefficients of skewness indicate right skewed distribution; the only exception is the Baltic Capesize Index (BDI_c) with a negative coefficient of skewness, which indicates a left skewed distribution for this time series. *J-B* is the Jarque-Bera statistic for testing whether the series is normally distributed. The reported probabilities indicate that *FRT* and *SBP* are broadly not normally distributed at the 5% level in all ship types.

4.5 Empirical Results and Discussion

4.5.1 Tests of non-stationarity

Before testing for cointegration between the shipbuilding price and the freight rate, we must first test their order of stationarity. Six commonly used tests are applied to test panel unit root, namely, *LLC* test by Levin, Lin and Chu (2002), Breitung test by Breitung (2000), *IPS* test by Im, Pesaran and Shin (2003), ADF Fisher test and PP Fisher test by Maddala and Wu (1999), and Hadri test by Hadri (2001).

Table 4-3 shows the results of panel unit root tests under six test methods. In the LLC, Breitung, IPS, ADF and PP tests, the null hypothesis is that the variables have unit roots. The null is accepted when variables are in their levels and rejected in their first differences. Hadri test has the null of no unit root, and the null is rejected when variables are in their levels and accepted in their first differences. All the variables are significant at the 1% level. Therefore, we conclude that all these variables are in *I*(1) form.

Table 4-3 Panel unit root tests

		Tests assuming common root			Tests assuming individual root	
Variables	LLC	Breitung	Hadri	IPS	ADF	PP
	H_0: Unit root	H_0: Unit root	H_0: No unit root	H_0: Unit root	H_0: Unit root	H_0: Unit root
Levels						
BDI	-0.082	-0.890	6.940*	-1.136	11.958	7.487*
TC1	-0.635	-1.287	8.511*	-2.285	14.719	3.445*
TC3	-1.366	-0.354	7.634*	-1.822	11.966	2.953*
SBP	0.386	1.841	12.465*	-0.241	5.191	4.725*
First Differences						
△BDI	-12.952*	-2.552*	-1.270	-11.537*	106.837*	109.932
△TC1	-12.857*	-4.892*	-0.880	-10.617*	96.133*	89.278
△TC3	-14.548*	-9.548*	-0.315	-11.055*	101.924*	82.253
△SBP	-9.432*	-7.784*	-0.332	-9.531*	83.965*	123.099

Note:

- Period: 1998:05 to 2009:05

- In the tests of Levin, Lin and Chu (2002, L.L.C.), Breitung (2000), Im, Pesaran and Shin (2003, IPS), ADF Fisher (ADF), PP Fisher (PP), the null hypothesis is with unit root. In the Hadri (2001) test, the null hypothesis is with no unit root.
- * denotes rejection of the null hypothesis at 1% critical value levels.
- The lag lengths of the ADF test is determined by Schwarz Info Criterion (SIC).

4.5.2 Cointegration between shipbuilding and freight

Having established that all the variables possess *I*(1) characteristics for long-run equilibrium relationship, we proceed to test panel cointegration between *SBP* and *FRT*.

To examine whether there is a long-term equilibrium relationship between *SBP* and *FRT*, we perform the seven panel cointegration tests. As shown in Table 4-4, the seven tests give different results for the three contract terms (*FRT=BDI, TC1* or *TC3*). In the case of *BDI* and *SBP*, all the seven test statistics show that there is cointegration between the two variables. In the case of *TC1* and *SBP*, five out of seven tests are significant, rejecting the null of no cointegration. In the case of *TC3* and *SBP*, six out of seven tests show the cointegration. Therefore, it is reasonable to say that *FRT* and *SBP* are overall cointegrated.

Table 4-4 Panel cointegration tests

Pedroni Panel Cointegration Tests		BDI vs. SBP		TC1 vs. SBP		TC3 vs. SBP	
		Stats.	Prob.	Stats.	Prob.	Stats.	Prob.
Panel cointegration Tests	Panel v-Statistic	5.008	0.000**	4.597	0.000**	4.363	0.000**
	Panel rho-Statistic	-2.526	0.006**	-2.165	0.015**	-2.948	0.002**
	Panel	-2.122	0.017**	-1.309	0.095*	-1.540	0.062*

	PP-Statistic						
	Panel ADF-Statistic	-3.268	0.002**	-3.506	0.000**	-3.464	0.000**
Group mean cointegration tests	Group rho-Statistic	-1.595	0.055*	-1.172	0.121	-1.860	0.032**
	Group PP-Statistic	-1.928	0.027**	-0.877	0.190	-1.160	0.123
	Group ADF-Statistic	-3.258	0.007**	-3.573	0.000**	-3.432	0.000**

Note:

- Period: 1998:05 to 2009:05
- All tests are under the null hypothesis of no cointegration.
- *(**) denotes rejection of the null hypothesis of a unit root at 10% (5%) critical value levels.
- The lag lengths of the ADF test is determined by Schwarz Info Criterion (SIC).

4.5.3 Causal directions

When two variables are cointegrated, one time series is useful in forecasting the other or there exists causality along at least one direction (*Granger, 1986*). The Granger causality test is conducted to find the direction(s) of the causal effect between the two variables. *Engle and Granger (1987)* pointed out that, if the variables are cointegrated, a pure Vector Autoregressions (*VAR*) in difference to test the existence of Granger causality will be miss-specified. The Vector Error Correction Model (*VECM*) is suggested to estimate cointegrated data. To make the results more robust, the *VECM* model have been tried to test the existence of Granger causality. The expanded *VECM* of Eq. 4-2 can be estimated by the ordinary least squares (OLS) regressions as denoted by Eq. 4-3 & 4-4:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{4-2}$$

where $y_t = (SBP_t \;\; FRT_t)'$

$$\Delta SBP_t = \sum_{i=1}^{p-1} a_{SBP,i} \Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{SBP,i} \Delta FRT_{t-i} + \alpha_{SBP} ECT_{t-1} + \varepsilon_{SBP,t} \tag{4-3}$$

$$\Delta FRT_t = \sum_{i=1}^{p-1} a_{FRT,i} \Delta SBP_{t-i} + \sum_{i=1}^{p-1} b_{FRT,i} \Delta FRT_{t-i} + \alpha_{FRT} ECT_{t-1} + \varepsilon_{FRT,t} \tag{4-4}$$

The null hypothesis that freight rate (*FRT*) does not Granger-cause shipbuilding price (*SBP*) in the first regression Eq. (4-3) is formed as H_0: $b_{SBP,i} = 0$. Similarly, in the second regression Eq. (4-4), the null hypothesis that SBP does not Granger-cause *FRT* is H_0: $a_{FRT,i} = 0$. The test statistic is the usual *F*-statistics. $a_{SBP,i}$, $b_{SBP,i}$, $a_{FRT,i}$ and $b_{FRT,i}$ are short-run coefficients, ECT_{t-1} is the error correction term. The coefficients (α_{SBP} and α_{FRT}) of the error correction term provide insights into the adjustment process of *SBP* and *FRT* towards equilibrium, and their signs show the direction of convergence to the long-run relationship. Table 4-5 shows the Granger causality test results through *VECM* in three sizes of bulk ships. The null hypothesis that *FRT* (= *BDI*, *TC1* or *TC3*) does not Granger-cause *SBP* is rejected at 1% critical value, while that the null hypothesis that *SBP* does not Granger-cause *FRT* is accepted at 10% critical value for three sizes of ships. Therefore, *FRT* are statistically significantly Granger-cause *SBP*. Our a priori hypothesis is therefore verified.

Table 4-5 Granger causality test: Capesize, Panamax and Handymax ships

Walt tests	*H₀*: $b_{SBP,i} = 0$	*H₀*: $a_{BDI,i} = 0$	*Walt tests*	*H₀*: $b_{SBP,i} = 0$	*H₀*: $a_{TC1,i} = 0$	*Walt tests*	*H₀*: $b_{SBP,i} = 0$	*H₀*: $a_{TC3,i} = 0$
Capesize Bulker series (1999:03-2009:05)								
	ΔBDI_{C_t}	ΔSBP_{C_t}		$\Delta TC1_{C_t}$	ΔSBP_{C_t}		$\Delta TC3_{C_t}$	ΔSBP_{C_t}
	31.535**	13.669		19.213**	10.252*		14.864**	12.010*
	(0.000)	(0.091)		(0.000)	(0.036)		(0.005)	(0.017)
Panamax Bulker series (1998:05-2009:05)								
	ΔBDI_{P_t}	ΔSBP_{P_t}		$\Delta TC1_{P_t}$	ΔSBP_{P_t}		$\Delta TC3_{P_t}$	ΔSBP_{P_t}
	53.128**	3.011		34.501**	3.363		46.924**	4.119
	(0.000)	(0.222)		(0.000)	(0.186)		(0.000)	(0.128)
Handymax Bulker series (2000:09-2009:05)								
	ΔBDI_{H_t}	ΔSBP_{H_t}		$\Delta TC1_{H_t}$	ΔSBP_{H_t}		$\Delta TC3_{H_t}$	ΔSBP_{H_t}
	50.778**	2.498		42.075**	3.118		42.711**	3.169
	(0.000)	(0.287)		(0.000)	(0.210)		(0.000)	(0.205)

Note:

- Figures in ( ) stands for P-values.
- The lag length of the VECM model is determined by Schwarz Info Criterion (SIC).
- *(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

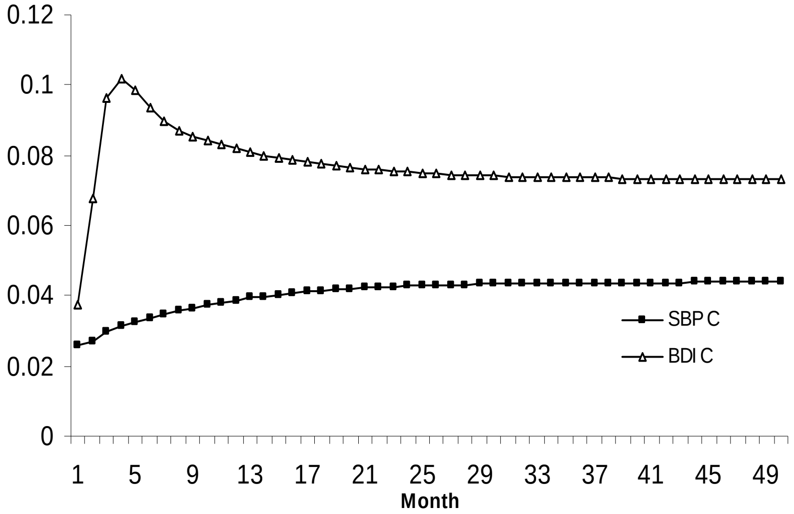
4.5.4 Response to impulse change

The impulse response analysis provides a more detailed insight in depicting the system dynamics. It is conducted to demonstrate the dynamic response of the system, which illustrates the two-way dynamic relations of the variables. An impulse response function provides a different way to depict the system dynamics by tracing the effects of the shock of an endogenous change on the variables in the *VECM*. The impulse response analysis shows how variables in the *VECM* system respond to a standard exogenous change of one variable. By providing a finer characterization of the causal relationship, the impulse response analysis indicates whether the impacts are positive or negative, and whether such impacts are temporary or long-termed.

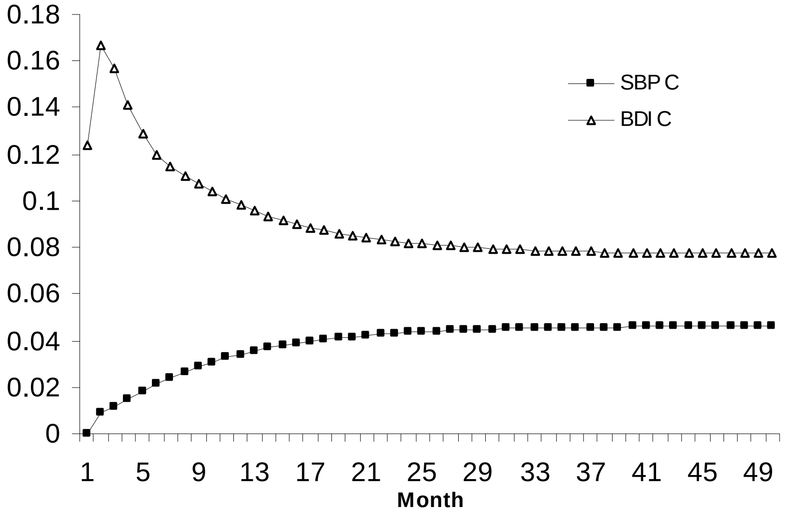
The impulse response analysis traces the effect of a one standard deviation shock to one of the innovation on current and future values of the endogenous variables. A shock to the *i*-th variable directly affects the *i*-th variable itself, and is also transmitted to all of the endogenous variables through the dynamic structure of the *VECM*. Sims's (1980) original approach depended on the ordering of the variables in a system (Lutkepohl, 1991). Pesaran and Shin (1998) suggested the use of generalised impulse responses by constructing an orthogonal set of innovations which resolved the problem of depending on the ordering of the variables in the system.

Figure 4-2 depicts the generalised impulse responses of *SBP* and *BDI* to one standard deviation innovation in capesize case. Appendices 4B and 4C further report *SBP* vs. TC1 and *SBP* vs. TC3's cases.

Figure 4-2 Generalised impulse responses of SBP_C & BDI_C : Capesize ships



In the equation for SBP_C



In the equation for BDI_C

A positive shock to *SBP* brings about an immediate increase in *FRT* (= *BDI*, *TC1*, *TC3*), and dies off very soon in about 12 months. A positive shock to *SBP* also brings about an increase to itself, but adjusts gradually to equilibrium, the overshooting of *SBP* dies off in about 6 months after *FRT* reaches the peak.

On the *FRT* to *SBP* direction, a positive shock to *FRT* brings about an immediate increase of itself in the first month and adjusts to equilibrium in much shorter time than SBP. A positive shock to *FRT* also brings about an increase in *SBP* and adjusts gradually to equilibrium in about 18 months, which is a longer period of adjusting time than the impact of *SBP* to *FRT*.

Both results of the impact of *SBP* to *FRT* and vice versa, which indicates that *SBP* needs a longer adjusting time to equilibrium than *FRT*. In other words, freight market responds to new information more rapidly than the shipbuilding market. This result is in line with the previous Granger causality test that freight rate seems to be more sensitive to market changes, freight rate plays a price-leading role in incorporating new market information.

These results suggest that a positive shock of *SBP* and *FRT* will bring about a positive adjustment to each other. However, with a stronger respond of freight rate to market shocks, shipbuilding price demonstrates a relatively slower adjustment to market shocks. This shows that there is a long-term relationship between freight and shipbuilding markets. However, the freight market is in the lead in price discovery, since new information tends to be processed more rapidly in the freight market than in the shipbuilding market.

4.5.5 Sensitivity analysis

As a further robustness check, we shorten the observation period (1998:05 – 2007:12) and replicate the preceding analysis. This period is chosen because there were the freight market boom (2003-2005) and the recent financial crisis (2008). It is expected that there may be fundamental change from the market boom in 2005 to financial crisis in 2008. This sensitive result (Appendix 4D) basically confirms and is consistent with the earlier analysis. There is no clear evidence that the freight market condition (boom and crisis) has substantially changed the directional relationship from freight to shipbuilding markets.

4.6 Lead-lag Relationship between Shipbuilding and Other Shipping Prices

Apart from testing the causal relationship between shipbuilding price and freight rate, we also test shipbuilding price versus second-hand ship price and shipbuilding price versus scrapping price. As shown in Table 4-6, no causal relationships were found between shipbuilding price and second-hand ship price, nor shipbuilding price and scrapping price. This shows that the future earning potential is shipowner's major consideration to build new ships. When the freight market is promising, shipowners will either build new ships or buy second-hand ships, shipbuilding price and second-hand ship price do not necessarily affect each other. To model the shipbuilding price as an index of expected future second-hand ship prices might not make practical sense.

Table 4-6 Summary of lead-lag relationships between shipbuilding price and other shipping prices: Capesize ship

Hypothesis	*Chi-sq*	*Prob.*	*Accept or Reject*
Freight rate doesnot lead Shipbuilding price	31.535	0.000	Reject
Shipbuilding price doesnot lead Freight rate	13.669	0.091	Accept
Second-hand price doesnot lead Shipbuilding Price	2.214	0.331	Accept
Shipbuilding price doesnot lead Second-hand Price	3.820	0.148	Accept
Scrapping price doesnot lead Shipbuilding price	1.353	0.508	Accept
Shipbuilding price doesnot lead Scrapping price	2.354	0.308	Accept

Note:

- Period: (1998:05-2009:05)
- Second-hand ship prices: 5 year old ships

4.7 Concluding Remarks

By focusing on the market-driven dynamic relationship between freight rate and shipbuilding price in the dry-bulk shipping sector, we have three conclusions. First, we find a strong positive one-way causal mechanism from freight rate to shipbuilding price in contrast to most existing studies, where a reverse relationship from shipbuilding price to second-hand ship price to freight rate is claimed. Second, our results are further verified using panel data and associated panel techniques while previous analyses of freight rate and shipbuilding price have been conducted using time series data or cross-sectional data only. Third, this chapter explains clearly the differences between different freight markets, classified by ship size, in the relationships between freight rate and shipbuilding price.

This chapter establishes an econometric model of shipbuilding price and freight rate to examine their dynamic relationship. Similar to many financial and economic time series, shipping time series are non-stationary. However, it has previously been believed that there exists a cointegration relationship between freight rate and shipbuilding price, such that the two rates are related to form an equilibrium relationship in the long run. Our results have revealed a positive correlation between freight market and shipbuilding market, and demonstrated the causal relationship that freight rate leads shipbuilding price.

This chapter concludes the interdependence of two shipping markets, where the sea freight market trades cargo-carrying service and the shipbuilding market trades new ships. The results of Granger causality test reject the directional relationship from shipbuilding price to freight rate. More specifically, our findings imply that, due to the long delivery time, the shipbuilding price does not lead the freight rate. The sensitivity analysis shows no clear evidence that the freight market condition (boom and crisis) has substantially changed the directional relationship from freight to shipbuilding markets.

The lags from freight rate to shipbuilding price are approximately three to six months (see Figure 4-2). The existence of time lags implies that the information flow between these two markets may not be as efficient as that expected by the Efficient Markets Hypothesis. This information delay is however expected because the market players are essentially different in these two markets, despite the fact that they are related. The market players in the freight market are ship operators and cargo owners who trade the cargo-carrying capacities, while shipowners and shipbuilders buy and sell the shipbuilding capacities in the shipbuilding market. One needs to analyse the respective pricing setting mechanisms in the two markets to clearly explain the time lags.

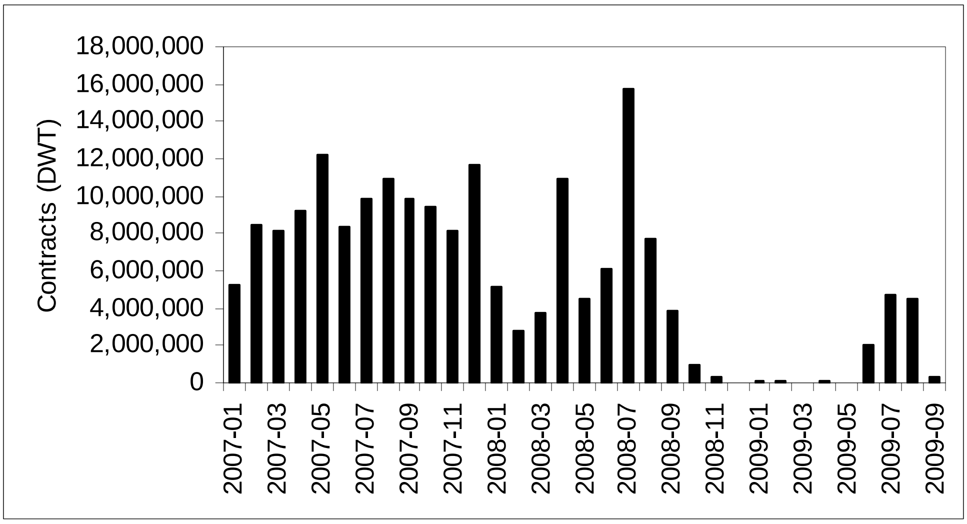
This chapter contributes a general understanding to the price interdependence between production market (cargo-carrying service) and economic capital market (new ships). The modern analysis of price interdependence among markets has been typically focused on the foreign exchange market, equity market and derivative markets, in which equilibrium pricing appears for the arbitrage free relationship among the markets. This chapter extends the area of the price interdependence across markets from financial derivatives markets into two apparently stand-alone markets. Our results indicate that the investment behaviour in physical assets for future service capacity is encouraged by a strong service market. The results further imply that market inefficiency is expected across markets, as the service market is more sensitive to the market changes than the asset market, while the asset market is much more capital intensive than the service market.

5 SHIPBUILDING ACTIVITIES AND POLICIES

5.1 Introduction

In the previous chapter, we discussed the relationship between freight market and shipbuilding market, we move on to study the cause of shipbuilding activities: shipbuilding order of ships. Ever since the financial crisis started around mid-2008, the global shipbuilding industry is not in a state of euphoria any more. As shown in Figure 5-1, the contract volume of booked new ships plummeted dramatically after August 2008, and not a single contract was received by worldwide ship builders for a whole month of May 2009. Ship investors want to either cancel the shipbuilding orders or put off the ship delivery dates. Ship manufacturers in the whole world are in a distressful situation. We are motivated to find in the context of shipping industry, which variable/variables play the most important role in a ship investment decision? Besides, shipbuilding industry has been known as an industry enjoying enormous government support and favorable investment conditions. Will these favorable policies really help to save shipbuilding industry from the distress?

Figure 5-1 Contracts received by ship builders worldwide (2007:01- 2009:09)



Source: Clarkson's Shipping Intelligence Network

Shipbuilding is a very attractive industry for a country as it can bring in substantial amount of foreign investment. Chapter 1 summarised about the shipbuilding evolution in Europe, Japan, South Korea and China. The United Kingdom was the leading shipbuilder in the first half of 20th century. Japan relied on shipbuilding in the 1950s and 1960s to rebuild its heavy industrial capacity. South Korea made shipbuilding a strategic industry for economic development in the 1970s. At present, China follows a similar pattern of shipbuilding developments in Japan and Korea.

We contribute to the literature on shipbuilding economics by studying the shipbuilding problem from a different angle. Previous analysis focused on the shipbuilding prices but we focus on the shipbuilding orders. The majority of previous studies assumed that the newly built ships and second-hand ships are perfect substitutes and their prices are linked according to the net present value. However, few of them analysed how and why the amount of shipbuilding orders fluctuates over time. We extend previous studies from the shipbuilding price to shipbuilding orders.

In this chapter, we examine three issues to better understand the economics of the shipbuilding market. First, what are the main determinants of the amount of shipbuilding order contracts? Research on shipbuilding market has attracted attention in the fields of maritime policy and international business. It is necessary to explain and determine how investors decide to invest in new ships. Second, shipbuilding industry has been known as an industry enjoying enormous government support and favorable investment conditions. Will these favorable conditions really help to save shipbuilding industry from the distress? Third, Japan, South Korea and China have been known as three leading shipbuilding countries, we test the cluster effect in shipbuilding industry. The remainder of this chapter is organised as follows: 5.2 Literature review, 5.3 Hypothesis Development and Methodology, 5.4 Data Description, 5.5 Empirical Results and Discussion, and finally 5.6 Concluding Remarks.

5.2 Literature Review

5.2.1 Economic overview of shipbuilding

There are 3 major propositions of shipbuilding, namely, supply-demand proposition, cost based proposition, and asset pricing proposition (Tsolakis, 2005).

The shape of the demand curve for shipbuilding has been studied by Stopford (2008) and others. When the shipbuilding price is high, the demand curve is of lower elasticity. It is because at this high shipbuilding price level, only those very few shipowners with very profitable trading opportunities will order new ships. At the lower end of shipbuilding prices, the number of shipbuilding orders will be limited owing to lack of trading opportunities, financial resources and longer delivery times from the shipbuilders. However, the demand and supply proposition is not practically useful. Firstly it gives a very static picture of the shipbuilding market and is of limited value for a dynamic analysis of the shipbuilding market. Secondly, shipyard capacity as the supply variable was proven to be a very difficult one to find data for. In the absence of shipyard capacity data, the demand and supply proposition cannot be applied in practice.

In the cost-based proposition, the shipbuilding cost is the most influential factor in determining the shipbuilding price. However, subsidies are commonly applied in the shipbuilding industry. The shipbuilding efficiency varies across yards. As a result, the shipbuilding cost is not a reliable indicator for the fluctuation in shipbuilding price.

The asset pricing proposition has been adopted in most studies, e.g. Beenstock and Vergottis (1989). Under this asset pricing proposition, newly built ships and second-hand ships are perfect substitutes with discounted time value, and. the shipbuilding prices co-move with second-hand ship prices over time.

Previous studies have mainly focused on the shipbuilding price. To our best knowledge, there is no rigorous study on the determinants of shipbuilding orders and how the incentive policy impacts the shipbuilding orders.

5.2.2 Determinants of ship investment

There have been a wide variety of studies on the determination of general investment behavior. The studies were conducted in different industries, i.e. manufacturing, real estate and shipping. These were done at different levels (the individual level and aggregate level), and through different econometric models. Different investigators thus have reached a broad range of conclusions across industries. The determinants of investment behavior also differ considerably from one model to another.

The determinants of investment can be discussed from micro-economic and macro-economic perspectives. At the firm level, the following two factors are considered by most studies: expected benefits and funds, i.e. changes in sales and profits and the level of capital stock, both in terms of availability and cost. Jorgenson (1965, 1967) developed and applied the neoclassical investment theory through many of his studies. Jorgenson, Hunter and Nadiri (1970) compared four econometric models of investment behaviors for individual manufacturing industry groups in the United States. The common variables they considered as the determinants of investment behaviors are: capital stock (Eisner, 1964; Jorgenson and Stephenson, 1965), capacity utilization (Anderson, 1967; Meyer and Glauber, 1964), profits (Anderson, 1967; Eisner, 1964; Meyer and Glauber, 1964) and interest rate (Anderson, 1967; Meyer and Glauber, 1964). They also included time structure in their models, be it lagged value of the independent variables or seasonal dummy variables. At the industrial level, Boatwright and Eaton (1972) studied the investment in plant and machinery in manufacturing industry in the United Kingdom. Apart from the common elements considered at the firm level, their study emphasized the impact of governmental incentive schemes on certain industries to stimulate investment. Their estimates of the effect of government scheme by separate techniques showed that the investment incentives are not as effective as the government would expect.

In shipping context, expectations include, for example, the state of the market, freight rates, changing costs, new technology, and flag of registry. Marlow (1991) wrote a trilogy about investment incentives and shipping industry, and his third paper specifically discussed the major determinants of investment in the UK shipping industry. Apart from the common determinants of investment behavior, expectation was also included as one of the variables. The results also showed no real relationship between investment incentives and the level of shipping investment in the UK shipping industry.

5.2.3 FDI as ship investment incentives

Shipbuilding is a very attractive industry for a country as it can bring a substantial amount of foreign direct investment. There has been plenty of research on the effect of fiscal policy and investment incentives on shipbuilding investment. Marlow (1991) mentioned that during the mid-1960s it was less common than before for shipowners to finance investment from their own funds. Since then the governmental investment schemes on shipping industry have become so favorable that the real rate of interest has been negative in some cases. Shipowners would naturally tend to obtain investment funds from other sources instead of their own funds, among which one of the most popular nowadays is foreign direct investment (FDI). There have been a handful of studies on the impact of FDI on the maritime industry. Kind and Strandenes (2002) analyzed the causes and effects of FDI in Asia by the Norwegian maritime industry. They mentioned that the strong cluster effect of Asian countries in the maritime sector explains why Norwegian maritime companies invest in Asia. It was shown that shipping companies engaged in FDI involve a large variety of firm types, such as port agencies, terminals, representative offices, and the shipbuilding and ship-repair companies. However, certain firm types attract more FDI than others, as Kind and Strandenes (2002) pointed out, host clusters seem to be more important for service providers in transportation or repair and maintenance markets than for industrial manufacturers.

5.2.4 Cluster effect

The literature assumes that the shipbuilding is a single global market, as the shipbuilding transaction is carried out largely in US dollars. Hennart and Park (1994) discussed the impact of the location factor on a firm's decision to manufacture abroad.

They hypothesized that '*the optimum location of production depends on plant economies of scale, transportation costs, tariff and non-tariff barriers, relative production costs, and on the presence of long-standing customers in the foreign market.*' Akselsen (2000), Tenold (2000) and Kind and Strandenes (2002) all discussed the location advantage to the shipping investment in their study of FDI and maritime industry, and the location advantage of the maritime cluster to the different home countries also differs, for example, the tax heaven, low transaction costs, low barriers to trade, and closer to customer market.

5.2.5 Shipbuilding policy

Kind and Strandenes (2002) used Singapore as an example to analyse the host country effects of FDI. They argued that the main reason why Norwegian maritime industry considers investing in Asia is the public policy there, which was formed to consciously encourage FDI in export oriented manufacturing and services.

Song (1990) discussed the shipping and shipbuilding policies in China. The author mentioned that the two industries were under greatest development ever and becoming increasingly important to China's national economy. Lee (1990) discussed the role of the Korean government in Korean shipping: the government plays both direct and indirect roles in Korean shipping growth. The paper also concluded that the expansion of shipping in Korea was a response to the export-oriented industrialization policy. King (1999) discussed the new directions in shipbuilding policy around the world in the 1990s. He mentioned shipbuilding policy in Europe is very different from other shipbuilding states, such as Japan, South Korea and China. While shipbuilding in the Europe has been more or less accepted by the industry and the academics as 'an out-dated and poorly managed' industry, in Japan, and later in South Korea and China, the shipbuilding industry has been identified as a key and strategic industry which has gained enormous government support and enjoys specially created green field sites with state protection. Although it is the commission and trend of these three countries (especially the OECD countries of Japan and South Korea) to restrict state aid to shipbuilding, the shipbuilding centre still seems to be shifting from the West to the East. As shown in Table 1-1, South Korea, China and Japan are the largest three shipbuilding countries and have received most shipbuilding orders around the world.

While previous studies are more about ship investment behavior of individual countries (Marlow, 1991; Kind and Strandenes, 2002), our estimations will be carried out using panel data analysis. The panel data aggregates all the individuals; this method allows us to model differences in behavior across individuals over time.

5.3 Hypotheses Development and Methodology

In this section, we presented our 8 hypotheses, which are designed to capture the major determinants of the amount of shipbuilding order contracts in deadweight tonnage (DWT). We then introduced how these hypotheses will be tested through panel data approach.

5.3.1 Capital stock hypothesis

The capital stock determines investment for replacement purpose. The shipping markets as a whole is measured by the tonnage of the fleet trading in the market; while the shipbuilding market is measured by the tonnage of the new vessel booked, namely orderbook. The capital stock can be translated into the investment net of replacement, according to the investment theories established, the higher the existing capital stock is, the less likely new capital will be invested in the market *(Eisner, 1964; Jorgenson and Stephenson, 1965; Marlow, 1991).*

Hypothesis 5-1: Variables representing capital stock, such as fleet size and existing orderbook are negatively related to the amount of shipbuilding order contracts.

5.3.2 Potential earning hypotheses

According to the potential earning hypothesis, the level of expected returns positively affects the level of investment. In the shipping context, the output can be measured by the demand for shipping, which depends on the international trade volume *(Anderson, 1967; Eisner, 1964; Meyer and Glauber, 1964; Marlow, 1991).*

Hypothesis 5-2: International trade volume of exports is positively related to the amount of shipbuilding order contracts.

Expectations influence the decision to invest. Marlow (1991) mentioned that expectations can be affected by many factors, namely the state of the market freight rates, changing costs, new technology, and flag of registry. We here test the hypothesis that freight rate, reflecting the market level, thus positively related to the amount of shipbuilding orders. We then formulate the following hypothesis.

Hypothesis 5-3: Freight rate, representing expectation-the state of the market, is positively related to the amount of shipbuilding order contracts.

Shipbuilding price can be translated into the changing costs in building the new ships. Therefore, its relationship with the amount of shipbuilding orders is negative.

Hypothesis 5-4: Shipbuilding price, representing expectation-changing costs in investing in new ships, is negatively related to the amount of shipbuilding order contracts.

Secondhand ship price can be translated into the changing costs in investing secondhand ships, as an alternative way of investing new ships. We hereby expect that secondhand ship price is positively related to the amount of shipbuilding orders.

Hypothesis 5-5: Secondhand ship price, representing expectation-changing costs in investing in secondhand ships, is positively related to the amount of shipbuilding order contracts.

5.3.3 Investment incentives hypothesis

Shipbuilding has been known as a very attractive industry for a country as it can bring a substantial amount of Foreign Direct Investment (FDI), shipbuilding investment therefore benefited from a lot of favorable investment incentives from the government. In order to test the effect of investment incentives on shipbuilding, we use FDI volume in transportation to represent the favorable fiscal policy and investment incentives on ship investment. FDI is among the most popular way for shipowners to obtain investment funds from other sources than its own funds, and the FDI volume also depends on the favorable fiscal policy and investment incentives on ship investment. We expect a positive relationship between FDI in transportation and the amount of shipbuilding orders.

Hypothesis 5-6: FDI in transportation is positively related to the amount of shipbuilding order contracts.

5.3.4 Location advantage hypotheses

As discussed, the location advantage to the shipping investment is enormous (Akselsen, 2000; Tenold, 2000; and Kind and Strandenes, 2002), and this location advantage can be reflected by the country's share of transportation service in total export services, which shows a large consumers' market for maritime transportation. Therefore, its relationship with the amount of shipbuilding orders is positive.

Hypothesis 5-7: Share of transportation service in total export services is positively related to the amount of shipbuilding order contracts.

Japan, China and South Korea have been known as the major maritime clusters. Shipbuilding industry has been identified as a key and strategic industry in these three countries. This hypothesis is designed to test the cluster effect to ship investment.

Hypothesis 5-8: Interactions between shipbuilding clusters and fleet size, trade volume and freight rate significantly contribute to the increase of the amount of shipbuilding order contracts.

5.3.5 The panel data approach

The data is collected from 15 major shipbuilding countries over the period from 1996 to 2008. The impact of each of the factors discussed varies from country to country, therefore, we apply panel data analysis in this chapter. The fundamental advantage of using panel data set over a cross section is that it allows great flexibility in modelling differences in behavior across individuals over time (Greene, 2008). The basic framework for this discussion is a regression model of equation 5-1:

$$y_{it} = x_{it}'\beta + z_i'\alpha + \varepsilon_{it} \tag{5-1}$$

Where x_{it} represents the regressors, $z_i'\alpha$ represents the heterogeneity, or individual effect, where z_i contains a constant term and/or a set of individual or group specific variables. There are several types of panel data analytic models, such as constant coefficients models, fixed effects models, and random effects models. We first need to consider the regression model.

One type of panel model has constant coefficients, referring to both intercepts and slopes. When there is neither significant country nor significant temporal effects, we can pool all of the data and run an ordinary least squares regression model. Although most of the time there are either country or temporal effects, there are occasions when neither of these is statistically significant. This model is called the pooled regression model. We apply F test on the change of the R squared value between the fixed effects model and the pooled regression model. We find it appropriate to model the data with pooled regression.

5.4 Data Description

In this chapter, the data set contains information of 15 major shipbuilding countries. The contracts received by these 15 countries account for 94.78% of the contracts received worldwide in 2008 (See Table 5-1). Our data set is annually based and covers the period from 1996 to 2008. The data sources we used in this chapter are from Clarkson’s Shipping Intelligence Network, OECD statistics and World Development Indicators from the World Bank Group.

Table 5-1 Contracts by country of build (2008)

Country	*DWT*	*Percentage*
Brazil	241,362	0.14%
Denmark	23,000	0.01%
Finland	10,000	0.01%
France	600	0.00%
Germany	468,550	0.28%
Italy	65,000	0.04%
Japan	25,976,539	15.46%
Netherlands	231,470	0.14%
Norway	56,300	0.03%
P.R. China	61,748,392	36.74%
Poland	82,100	0.05%
South Korea	69,411,961	41.30%
Spain	144,200	0.09%
Turkey	771,600	0.46%
USA	56,670	0.03%
Total		94.78%

Source: Clarkson's Shipping Intelligence Network

Our basic model consists of the following 6 variables: the volume of ordered new ships in each period, i.e. the amount of shipbuilding order contracts (CONTRACT), represents the spot ship investment activities; Total world fleet size (FS) and total world orderbook (ORDERBOOK), imply the supply of shipping service; International trade volume of exports in goods (TRADE), implies the demand for shipping service; ClarkSea freight Index (FREIGHT), indicates the freight level of shipping market; and Gross domestic product per capita (GDPPC), serves as the control variable of local economic level. We further add shipbuilding price (SBP), secondhand ship price (SHP), foreign direct investment in transportation (FDI), share of transportation service in total export services (TS) to the basic model. Finally, a dummy variable (CLUSTER) is included to reflect the cluster effect of the three major shipbuilding countries (Japan, South Korea and China). The measurements and sources of the variables are listed in Table 5-2. Hypotheses designed to test these variables will be explained later. The descriptive statistics of the variables (number of observations, mean, standard deviation, maximum, and minimum) are presented in Table 5-3. In this chapter, estimations are carried out using panel data analysis through the EViews 6 program.

Table 5-2 List of variables

Variable	***Source***	***Description***
CONTRACT	SIN data	Contract: Contracts By Area/Country of Build (DWT)
FS	SIN data	Fleet Size: Total world fleet (Million DWT)
ORDERBOOK	SIN data	Orderbook: Total world Orderbook in (Million DWT)
TRADE	OECD statistics	Trade: International trade of exports in goods (Billion US dollars)
FREIGHT	SIN data	Freight: ClarkSea Index
GDPPC	WORLD BANK	Gross Domestic Product Per Capita
FDI	OECD statistics	Foreign Direct Investment: FDI inward flows in transports (Million US dollars)
TS	WORLD BANK	Transportation Service: Share of transportation service in total export services (%)
SBP	SIN data	Shipbuilding price: Shipbuilding Price Index
SHP	SIN data	Secondhand ship price: Total Sales Volume (DWT)
Dummy Variable		
CLUSTER		Japan, South Korea and China: 1 Other countries: 0

Table 5-3 Descriptive statistics of the variables

Variable	*Observations*	*Mean*	*Std. Dev.*	*Maximum*	*Minimum*
CONTRACT	194	12.921	2.476	18.527	5.165
FS	195	6.767	0.124	7.028	6.616
ORDERBOOK	195	4.946	0.604	6.261	4.281
TRADE	195	2.706	1.076	4.797	0.671
FREIGHT	195	9.782	0.427	10.378	9.184
FDI	126	6.660	1.993	11.369	0.000
TS	177	3.220	0.445	4.097	2.225
SBP	195	4.894	0.198	5.215	4.663
SHP	195	17.700	0.373	18.321	17.078
GDPPC	180	9.684	1.069	11.320	6.555
Dummy Variable					
CLUSTER	Japan, South Korea and China: 1 Other countries: 0				

5.5 Empirical Results and Discussion

We develop 9 models to test our hypotheses and report them in Table 5-4. All the 9 models are with a considerably high adjusted R squared value of around 0.7. The F statistics also show that the independent variables (except the variables SBP, SHP and FDI in the Models 5-4, 5-5 and 5-6) as a group explain a statistically significant share of variation in the dependent variable. Model 5-2 and Model 5-3 are basic models containing variables in Hypotheses 5-1 to 5-3, variables in Hypotheses 5-4 to 5-8 are added to the basic model through Model 5-4 to Model 5-10.

5.5.1 Capital stock results

Hypothesis 5-1, concerning capital stock (fleet size and orderbook), is tested throughout the 9 models. This hypothesis is confirmed by 7 out of 9 models. We separately test ORDERBOOK in Model 5-3, and choose FS to represent capital stock in the other 8 models. As can be observed in Table 5-4, both FS and ORDERBOOK are negatively related to the amount of shipbuilding orders. This finding is in line with our theoretical consideration, since the higher the existing capital stock is, the lower the investment net of replacement will be.

5.5.2 Potential earning results

Hypothesis 5-2 is confirmed by 8 out of 9 models: international trade volume of exports and the amount of shipbuilding orders are positively related, given that higher level of demand in ships requires more investment in the market.

Hypothesis 5-3 is also accepted by 8 out of 9 models, a higher freight rate indicates a prosperous shipping market, which makes shipowners expect a high return in freight market, thus willing to invest new ships. Among the three basic variables (FS, TRADE and FREIGHT), FREIGHT is the most significant one, this observation tells us that shipowners will be willing to invest new ships most when they confide in a profitable freight market. The supply of the market (fleet size) and the demand of the ships (trade volume) are also among their considerations, but not as important as the freight level factor.

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 GDPPC_t + \varepsilon_t$$

(5-2)

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 ORDERBOOK_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 GDPPC_t + \varepsilon_t$$

(5-3)

Model 5-4 is designed to test Hypothesis 5-4. Since a higher shipbuilding price implies higher opportunity costs in building new ships, we expect a negative relationship between shipbuilding price and the amount of shipbuilding orders. However, Hypothesis 5-4 is not confirmed according to Model 5-4's result, the variable SBP is not statistically significant as reported in Table 5-4. Shipbuilding price is thus proved to be insignificant to the amount of shipbuilding order contracts.

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 SBP_t + \beta_6 GDPPC_t + \varepsilon_t$$

(5-4)

Hypothesis 5-5, tested by Model 5-5, could not be proved either. The variable SHP is not statistically significant to the amount of shipbuilding orders. The rejection of Hypotheses 5-4 and 5-5 suggests that the cost changes on building new ships do not affect shipowners' decision of investing new ships. One possible reason for this is that the cost changes only take a small proportion of the total investment of building new ships, hence the shipowners care much more on the total sunk cost and the future payoff of the ships.

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 SHP_t + \beta_6 GDPPC_t + \varepsilon_t \tag{5-5}$$

5.5.3 Investment incentives results

Hypothesis 5-6, which relates to the effect of FDI on the amount of shipbuilding orders, is tested through Model 5-6. The result of Model 5-6 as can be observed in Table 4 failed to show a positive relationship between FDI volume and the amount of shipbuilding orders. This can be explained as: It has been found that service providers in transportation or repair and maintenance markets attract more FDI than industrial manufacturers (Kind and Strandenes, 2002). Therefore, the higher FDI volume in the host country does not necessarily lead to more investment on new ships.

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 FDI_t + \beta_6 GDPPC_t + \varepsilon_t \tag{5-6}$$

5.5.4 Location advantage results

Hypothesis 5-7 is confirmed by the results of Models 5-7 to 5-10 in Table 5-4, that is, the variable TS is positive and highly significant to the variable CONTRACT. A large share of transportation service in total export services shows the presence of long-standing customers' market of shipping service, which shows the country's location advantage. This result is therefore supported by many studies discussing about the enormous cluster advantage to the shipping investment (Akselsen, 2000; Tenold, 2000; Kind and Strandenes, 2002).

$$\begin{aligned} CONTRACT_t &= \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 TS_t \\ &+ \beta_6 GDPPC_t + \varepsilon_t \end{aligned} \tag{5-7}$$

Models 5-8 to 5-10 further test Hypothesis 5-8, relating to the interactions between shipbuilding clusters and fleet size, trade volume and freight rate, respectively. Japan, China and South Korea have been known as the major shipbuilding clusters. The results in Table 5-4 show that the interactions variables significantly contribute to the increase of the amount of shipbuilding orders, which can be interpreted that: with the same levels fleet size, trade volume and freight rate, the shipbuilding clusters, namely Japan, South Korea and China, still attract more contracts of shipbuilding. Possible reasons are the economies of scale for shipbuilding and a large consumers' market for maritime transportation. This finding is in accordance with the real situation:

shipbuilding industry has been identified as a key and strategic industry in these three countries in recent years. This result shows the great importance of the cluster effect to ship investment.

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 TS_t \\ + \beta_6 CLUSTER * FS + \beta_7 GDPPC_t + \varepsilon_t \tag{5-8}$$

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 TS_t \\ + \beta_6 CLUSTER * TRADE + \beta_7 GDPPC_t + \varepsilon_t \tag{5-9}$$

$$CONTRACT_t = \beta_0 + \beta_1 CONTRACT_{t-1} + \beta_2 FS_t + \beta_3 TRADE_t + \beta_4 FREIGHT_t + \beta_5 TS_t \\ + \beta_6 CLUSTER * FREIGHT + \beta_7 GDPPC_t + \varepsilon_t \tag{5-10}$$

Table 5-4 Pooled OLS estimations of the amount of shipbuilding order contracts models

Variables	***Models***								
	5-2	**5-3**	**5-4**	**5-5**	**5-6**	**5-7**	**5-8**	**5-9**	**5-10**
Dep.Var.	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**	**No. Obs.**
$CONTRACT_t$	**163**	**163**	**163**	**163**	**113**	**162**	**162**	**162**	**162**
$CONTRACT_{t-1}$	0.793**	0.799**	0.791**	0.799**	0.866**	0.662**	0.449**	0.461**	0.450**
	(15.720)	(15.946)	(15.609)	(15.742)	(14.218)	(10.910)	(6.216)	(6.449)	(6.206)
FS	-3.903*		-4.670*	-4.798*	-6.214**	-3.441*	-2.659	-2.935*	-2.607
	(-2.089)		(-2.146)	(-2.340)	(-2.926)	(-1.904)	(-1.565)	(-1.726)	(-1.530)
ORDERBOOK		-1.140**							
		(-2.706)							
TRADE	0.211*	0.212*	0.212*	0.203*	0.210	0.458**	0.309*	0.293*	0.309*
	(1.750)	(1.781)	(1.758)	(1.681)	(1.335)	(3.376)	(2.364)	(2.215)	(2.360)
FREIGHT	1.259**	1.633**	1.023*	0.809	1.527**	1.158**	1.108**	1.084**	1.068**
	(2.894)	(3.385)	(1.848)	(1.330)	(3.106)	(3.675)	(2.809)	(2.735)	(2.697)
SBP			0.925						
			(0.691)						
SHP				0.716					
				(1.058)					
FDI					-0.003				
					(-0.037)				
TS						1.158**	0.850**	0.875**	0.845**
						(3.675)	(2.816)	(2.896)	(2.789)
CLUSTER* FS							0.301**		
							(4.795)		

CLUSTER* TRADE								0.579**	
								(4.672)	
CLUSTER* FREIGHT									0.207**
									(4.727)
GDPPC	-0.215*	-0.208*	-0.218*	-0.211*	-0.257	-0.516**	-0.251*	-0.265*	-0.251*
	(-1.986)	(-1.943)	(-2.014)	(-1.954)	(-1.296)	(-3.858)	(-1.831)	(-1.938)	(-1.830)
Constant	18.353*	-6.240*	21.399*	16.009	30.773**	16.130*	12.805	14.875*	12.862
	(1.920)	(-1.832)	(2.030)	(1.632)	(2.797)	(1.744)	(1.475)	(1.712)	(1.478)
Adjusted *R*-squared	0.697	0.703	0.696	0.698	0.715	0.719	0.753	0.753	0.755
F-statistic	75.695	77.660	62.949	63.314	47.837	69.966	71.765	71.146	71.419

Notes: *t*-statistics in parentheses

** indicates significance at the 1% level

* indicates significance at the 10% level

5.5.5 Robustness tests

We perform robustness tests to check whether the shipbuilding environment remained unchanged from 1996 to 2008. To obtain an intuitive sense of our testing object, we examined the share of shipbuilding orders received by Japan, South Korea, China, Europe and other areas from 1996 to 2009, as shown in Figure 1-4. One may notice that the shipbuilding in China experienced a tremendous change before and after 2002, and the amount of contracts China received in recent years is steep-rising. Before 2002, the shipbuilding orders of China were significantly lower than Korea and Japan. In 2009 China's contracts in DWT surpassed South Korea and was still growing with a fast pace. Therefore, for the purpose of robustness tests, we divide the testing period into 1996 to 2001 and 2002 to 2008 to test whether there are noticeable changes of the results. The results reported in Appendices 5A and 5B show, while the significance level of the interaction effect is lower for the period of 2002 to 2008, the variables remain in general unchanged for the two sub-periods, expect for the cluster effect. This finding suggests that our results are robust. We further split the cluster dummy variable into three dummies: China, South Korea and Japan, in order to check their cluster effects separately. The results reported in appendices 5C to 5E show that China dummy variables tend to be not as significant as Japan and South Korea dummies. A possible explanation is that shipbuilding industry in China has been catching up with Japan and South Korea and did not exhibit strong performance in the first sub-period.

5.6 Concluding Remarks

In summary, our estimations through pooled panel data analysis show that the three basic variables, i.e. world fleet size, world trade volume, and spot freight rate, are important to the amount of shipbuilding orders. The spot freight level factor contributes more to the ship investment decision than the market supply and demand factors (fleet size and trade volume). This finding implies how important the shipowners' confidence in freight market is when they decide whether to invest new ships. Shipbuilding price and secondhand ship price, reflecting the changing costs of shipbuilding, were proved to have no linkage to the amount of shipbuilding orders. Moreover, the FDI volume in transportation in the host country does not necessarily lead to more investment on new ships. With regard to location factor and cluster effect, we find that location advantage and cluster effect are of great help to attracting more shipbuilding orders.

In terms of those hypotheses that were rejected, shipbuilding price and secondhand ship price do not affect ship investment behavior as we hypothesise, since the shipowners tend to be more cautious on the total sunk cost and the future payoff of the ships, rather than the relatively small proportion of changing costs on building new ships. The FDI effect to the amount of shipbuilding orders is different from what we assumed, but the higher FDI volume in the host country does not necessarily induce more shipbuilding orders. There are two reasons. First, FDI volume depends a lot on the favorable fiscal policy and investment incentives of the host country, while there is no real relationship between investment incentives and the level of shipping investment. Second, FDI in transports very likely involves more in service providers in transportation or repair and maintenance markets rather than industrial manufacturers.

Comparing the significance level of freight level factor and other determinants of the amount of shipbuilding orders, it was felt that only if the freight market became prosperous again, we would then expect a prosperous shipbuilding market. It has also been observed the strong cluster effect of Asian countries in the shipbuilding sector, namely Japan, South Korea and China. With the same levels of fleet size, trade volume and freight rate, shipowners will still go to these leading shipbuilding nations to build new ships. This shows a great cluster advantage of these three countries for being a large consumers' market for maritime transportation. The governments may wish to think about ways other than investment incentives to keep up with this trend of being the shipbuilding centre.

6 FLEET SIZE AND FREIGHT VOLATILITY

6.1 Introduction

We discuss shipbuilding order of ships in the previous chapter, we now move forward to discuss what the shipbuilding order will in turn affect the shipping market when it is delivered. The duration from shipbuilding order to final delivery may take two years or longer. When the ship is delivered, it immediately constitutes the new ship supply of the market, the fleet size trading in the market thus changes, and in turn the freight rate level is affected, the freight market situation may become totally different by then.

Freight volatility denotes the variability or the dispersion of the freight rate. The larger the freight volatility is, the more the freight rate fluctuates. Previous studies showed that freight volatility can be forecast but based largely on its past values (Kavussanos, 1996; Kavussanos, 2003). An abundance of research has been carried out in an attempt to understand the time-varying characteristics of freight rate volatility (Kavussanos, 1996; Kavussanos, 2003; Lu, Marlow and Wang, 2008; among others), yet few have discussed the relationship between freight rate volatility and other market factors: in other words, what impacts volatility and what causes this time-varying risk in shipping markets. The exceptions we find are Kavussanos and Visvikis (2004) and Batchelor, Alizadeh and Visvikis (2005) whose work aims to manage shipping risk by analysing the impact of the volatility of shipping derivatives. We are left with the question of what causes this time-varying freight volatility.

In the stock market, the positive relationship between stock price volatility and trading volume has been widely confirmed (see, for example, Gallant, Rossi and Tauchen, 1992; Jones, Kaul and Lipson, 1994). The trade volume in the stock market is defined as market capacity. There are thousands of buyers and sellers trading in the market and, according to the efficiency market hypothesis, if the amount of traders does not change rapidly, the market should behave in a less volatile manner. We therefore claim that the market risk depends on a certain market size (see also, for example, Furceri and Karras, 2007).

In financial risk management, the CAPM (Capital Asset Pricing Model) has been widely accepted as high risk denoting high return, and most research has attempted to determine the risk level of individual companies. However, the systematic (or market) risk is not well determined. There are few markets like shipping with such characteristics as the supply capacity being well defined and the size of supply inelastic to market rate. In other markets, it may be difficult to measure the capacity of supply or the supply is not fixed. This chapter aims to find the relationship between the time-varying volatility of dry bulk freight rates and the supply of fleet trading in the dry bulk market, namely, fleet size.

Imagine a market for any goods where initially there is only one buyer and one seller. Later more buyers and more sellers with more capital join the trade, one seller has more goods to sell or one buyer has more capital to buy. This may increase uncertainty in the market. This scenario could be extended to the shipping market. To better understand our argument, we proceed to examine our a priori hypothesis: similar to the stock market, in dry bulk shipping markets, the increase in the change of the size of fleet trading in the market leads to an increase in freight rate volatility.

In general, previous studies of freight markets focus on the modelling of freight rates assuming the market remains static (see, for example, Beenstock and Vergottis, 1993), or on estimating the freight rate volatility of individual markets (see, for example, Kavussanos, 1996). We study the dynamics between the time-varying freight rate volatility and fleet size as an indicator of supply capacity. The aim of this chapter is to determine the size effects of fleet on the market risk in shipping.

The remainder of this chapter is organised as follows. 6.2 reviews the related literature. 6.3 discusses the research framework and methodology. 6.4 describes the data properties. 6.5 discusses the empirical results. Finally, 6.6 summarises the findings.

6.2 Literature Review

Freight risk has been a core subject in maritime studies because shipping markets have generated alternative investment opportunities attracting the interest of investor groups in the last decade. Previous research into freight volatility has emphasised the properties of freight volatility but the determinants of freight volatility have been neglected.

6.2.1 Time-varying characteristics of shipping risks

Kavussanos (1996) applied the ARCH model to shipping markets for the first time. He extended the model to investigate volatility of the spot and time-charter rates in the dry bulk shipping market. He found that risks in both freight and time-charter dry bulk markets are time-varying and risk is generally higher in the time-charter market than the spot market and higher for larger ships than smaller ones. Kavussanos (2003) further employed the GARCH model to examine the risks in the tanker freight market and found that the risks in the tanker market vary over time. Time-charter rates have lower volatility than spot rates, while the freight rate of larger vessels has higher volatility than that of smaller ones. Lu, Marlow and Wang (2008) investigated the characteristics of freight rate volatility in three different types of bulk vessel using recent data from March 1999 to December 2005. Applying the GARCH model, they verified the time-varying behavior of dry bulk freight rates and found that market shocks have different magnitudes of influence on volatility in different vessel sizes and different time periods. The above studies illustrate that the time-varying behavior of freight rates has been verified in a wide range of shipping studies. Besides the freight rates, an abundance of empirical work on shipping markets has also applied this methodology to model second-hand ship prices (Kavussanos, 1997), risk premium in freight markets (Kavussanos and Alizadeh, 2002b; Adland and Cullinane, 2005), and freight futures markets (Kavussanos and Visvikis, 2004; Kavussanos, Visvikis and Batchelor, 2004; Batchelor, Alizadeh and Visvikis, 2005); all these shipping related time series are shown to exhibit time-varying volatilities.

6.2.2 Price volatility research in different contexts

Despite this abundant research into the time-varying characteristics of shipping risks, there has been little done which discusses the relationship between the price volatility and other variables. In other words, what impacts price volatility and what causes this time-varying risk in shipping. The exceptions are Kavussanos and Visvikis (2004) and

Batchelor, Alizadeh and Visvikis (2005). Kavussanos and Visvikis (2004) discussed market interactions in returns and volatilities between spot and forward shipping freight markets. Batchelor, Alizadeh and Visvikis (2005) examined the relationship between Forward Freight Agreement (FFA) price volatility and bid-ask spread (BAS). They first applied AR-GARCH(1,1) model to estimate the FFA volatility, then used General Methods of Moments (GMM) to examine the relationship between FFA volatility and BAS. The results indicate a positive relationship between FFA volatility and BAS on certain routes, which shows that risk is a stable determinant of future direction of FFA market.

In different contexts of volatility research, there have been plenty of studies on the relationship between price volatility and other factors, such as foreign exchange market (Bollerslev and Melvin, 1994), stock market (Gallant, Rossi and Tauchen, 1992),and macroeconomic studies (Hnatkovska and Loayza, 2004), among others. Special attention has been paid to the relationship between volatility and the size effect. Furceri and Karras (2007) considered the effect of country size on business cycle volatility. They found that the relationship between country size and business cycle volatility is negative and statistically significant, which implies that country size matters in terms of cyclical fluctuation. Fatas and Mihov (2001) indicated a strong negative correlation between government size and output volatility both for the OECD countries and across US states. Andres, Domenech and Fatas (2008) studied alternative models to testify the fact that a large government size is related to a less volatile economy. Both their initial model and modified models show that consumption volatility is reduced when government size increases. According to these studies concerning macroeconomic indices,a larger scale relates to less volatile economies. However, in the stock market, the positive relationship between stock price volatility and trading volume has been widely confirmed. Gopinath and Krishnamurti (2001) examined the Nasdaq stock market, and Tai, Chiang and Chou (2006) studied the Taiwan OTC stock market. Both their findings show that the larger the trading volume (namely the number of transactions), the higher the price volatility. Gallant, Rossi and Tauchen (1992) also found a positive relationship between conditional stock price volatility and volume. The daily trading volume is positively and nonlinearly related to the magnitude of the daily price change. Jones, Kaul and Lipson (1994) testified to the positive correlation between volume of trade and stock-return volatility.

These observations about price volatility and size effect in other fields left us wondering about the situation in the shipping market. We aim to find the relationship between the time-varying volatility of dry bulk freight rates and the supply of fleet trading in dry bulk market.

6.3 Research Framework and Methodology

We employ a two-step modelling to examine the relationship between freight market risk and fleet size. The first step is the measurement of freight rate volatility through AR-GARCH model. With the freight rate volatility to represent freight market risk, we proceed to the second step: the analysis of the relationship between freight market risk and fleet size through GMM Regression.

6.3.1 Freight rate volatility modelling: a two-step model specification

Most previous studies which model the freight market (see, for example, Beenstock and Vergottis, 1993; Kavussanos, 1996; Kavussanos, 2003) have concentrated on explaining the determinants of freight rate (*FR*) utilizing the following three variables:

Freight rate = f(Fleet size, Industrial production, Bunker price)

where fleet size (*FS*) indicates the supply of fleet trading in shipping market, industrial production (*IP*) denotes the demand for shipping services, and bunker price (*BP*) reflects the transportation costs. According to the empirical results, *IP* and *BP* are found to positively affect *FR*, while *FS* has a negative effect on *FR*. There have been abundant studies analysing the determinants of freight rate and estimating freight market volatility.

We attempt to determine the size effects of fleet on the freight rate volatility. To analyse the relationship between them, the freight rate volatilities are regressed against variables that represent the supply of fleet, the demand for shipping services, and the transportation costs.

Freight volatility = f (Fleet size, Fleet size squared,

Freight rate, Industrial production, Bunker price)

$$h_t = C_0 + C_1 \ln FS_t + C_2 \ln FS_t{}^2 + C_3 \ln FR_t + C_4 \ln IP_t + C_5 \ln BP_t + u_t \qquad (6\text{-}1)$$

where the freight rate volatility in logarithm (h_t) is defined as the one-step ahead conditional volatility of freight rate from a GARCH model, the supply of dry cargo fleet is evaluated by $\ln FS_t$ and $\ln FS_t^2$, the freight level by $\ln FR_\mathrm{t}$, the demand for shipping services by $\ln IP_\mathrm{t}$, and the transportation costs by $\ln BP_\mathrm{t}$. The second order term of fleet size is included in the regression according to Ramsey's RESET Test, which is a general test for mis-specification that may manifest itself in terms of missing variables and/or incorrect functional form. It should be noticed that Equation 6-1 is in the log-log specification and the estimated coefficients measure the change in volatility per unit change in explaining variables.

6.3.2 AR-GARCH model: the measurement of freight rate volatility

This chapter employs a two-step model specification. The first step is the measurement of freight rate volatility. The price volatility has been measured in two ways in related literatures.

(1) The volatility is assumed to be stationary, measured by standard deviations of different samples or observations (see, for example: Hnatkovska and Loayza, 2004; Rose, 2006; Furceri and Karras, 2007).

(2) Alternatively, the volatility is non-stationary, measured by continuous time-changing variances of the same sample (see, for example: Kavussanos, 1996 and 2003; Adland and Cullinane, 2005; Lu, Marlow and Wang, 2008). The latter approach is used in this chapter to verify the time-varying characteristics of shipping risks.

The approach to determine the dynamic volatility is associated with the following remarks. The Autoregressive Conditional Heteroskedasticity (ARCH) and Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models are employed commonly in modelling volatility of financial time series that exhibit time-varying volatility clustering, that is, periods of swings followed by periods of relative calm. The ARCH model was introduced by Engle (1982) to model the volatility of UK inflation. Since then this methodology has been employed to capture the empirical regularity of non-constant variances, such as stock return data, interest rates and foreign exchange rates (Bollerslev and Melvin, 1994, among others). However, this methodology, despite its abundance of results elsewhere, had not been applied before in shipping markets until Kavussanos (1996) for the first time implemented ARCH and GARCH models to analyze the time-varying behavior in freight rates. The time-varying characteristic of the volatility has been found to exist among most shipping related time series, for example, bulk shipping freight rate (Kavussanos, 1996; Adland and Cullinane, 2005), second-hand ship price (Kavussanos, 1997), forward freight agreement (FFA) price (Batchelor, Alizadeh and Visvikis, 2005). The GARCH model has been widely used to examine the time-varying volatilities of shipping related time series. The ARCH model considers the variance of the current error term to be a function of the variances of the previous time period's error terms. ARCH relates the error variance to the square of a previous period's error. As the name suggests, the model has the following properties:

(1) Autoregression - Uses previous estimates of volatility to calculate subsequent (future) values. Hence volatility values are closely related.

(2) Heteroskedasticity - The probability distributions of the volatility varies with the current value.

In this chapter, we apply AR-GARCH to model the conditional volatility of freight rate. GARCH model adequately fits many economic time-series (Bollerslev, 1987). AR-GARCH is a composite model consisting of an autoregressive process and a GARCH error term. It captures the change of the time series itself. AR-GARCH model has been proved to be effective in modelling the volatility of shipping related time-series (Batchelor, Alizadeh and Visvikis, 2005).

$$r_t = b_0 + b_1 r_{t-1} + b_2 r_{t-2} + \cdots + b_m r_{t-m} + \varepsilon_t , \qquad \varepsilon_t \sim iid(0, h_t) \tag{6-2}$$

$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1} \tag{6-3}$$

where r_t is the natural logarithm of the monthly freight rate change evaluated by first difference of monthly freight rate $r_t = \Delta \ln FR_t$. ε_t is the error term that follows a normal distribution with mean zero and time-varying variance h_t.

6.3.3 GMM Regression

Using the freight rate volatility (h_t) derived from AR-GARCH model to represent freight market risk, we then analyse the relationship between freight market risk and fleet size. h_t is regressed against the supply of dry cargo fleet by $\ln FS_t$ and $\ln FS_t^2$, the freight level by $\ln FR_t$, the demand for shipping services by $\ln IP_t$, and the transportation costs by $\ln BP_t$, as shown in Equation 6-1. We first employed Ordinary Least Squares (OLS) to test the result. However, OLS or Generalized Least Squares (GLS) often lead to inconsistent estimation. The coefficient value or significant level may be seriously upward biased due to failures of some assumptions, such as collinearity, autocorrelation, and heteroscedasticity, which imply inefficient standard errors.

Thus, we consider estimating the model using the generalized method of moments (GMM) approach. GMM is a very general statistical method for obtaining estimates of parameters of statistical models. In the twenty years since it was first introduced by Hansen (1982) of the method of moments, GMM has become a very popular tool among empirical researchers. It is also a very useful heuristic tool. Many standard estimators, including instrument variable (IV) and ordinary least squares (OLS), can be seen as special cases of GMM estimators.

GMM is a good estimator for dealing with autocorrelation and heterogeneity issues. The GMM approach allows an instrument to be used, thereby avoiding any simultaneity bias. It also brings the advantage of consistent estimation in the presence of heteroscedasticity and autocorrelation (Newey and West, 1987). Baum et al (2003) also mentioned that GMM makes use of the orthogonality conditions to allow for efficient estimation in the presence of heteroskedasticity of unknown form.

6.4 Data Description

In the analysis, the data sets consist of monthly freight rate, fleet size (*FS*, in million DWT), industrial production (*IP*, in index) and bunker price (*BP*, in $/ton). The freight rate is specified into Panamax and Capesize spot rate (*SPR*, in $/ton) and one-year time-charter rate (*TCR*, in $/day) in the dry bulk shipping industry while the fleet size is also divided into Panamax and Capesize bulk carriers (*FS_p*, *FS_c*) as two types of dry bulk supply. The samples for Panamax spot rate (*SPR_p*) and Capesize spot rate (*SPR_p*) cover the period from January 1973 to April 2008, the sample for Panamax time-charter rate (*TCR_p*) covers the period from January 1976 to April 2008 and Capesize time-charter rate (*TCR_c*) from January 1977 to April 2008. All freight rates, fleet size and bunker price data are collected from Clarkson Securities Limited, while the industrial production indices are from OECD Statistics. The time series are transformed into natural logarithmic form. In Table 6-1, we list the source and description of the variables.

Table 6-1 List of variables

Variable	***Source***	***Description***
SPR_p	SIN data	Spot rate: Panamax (\$/ton)
TCR_p	SIN data	One-year time-charter rate: Panamax (\$/day)
FS_p	SIN data	Fleet Size: Total Panamax bulk carriers (Million DWT)
SPR_c	SIN data	Spot rate: Capesize (\$/ton)
TCR_c	SIN data	One-year time-charter rate: Capesize (\$/day)
FS_c	SIN data	Fleet Size: Total Capsize bulk carriers (Million DWT)
IP	OECD statistics	Industrial production (index)
BP	SIN data	Bunker price (\$/ton).

Descriptive statistics of logarithmic first difference freight rates and fleet size are presented in Table 6-2. The *J-B* statistic rejects the hypotheses of normality for freight rates and fleet size in both ship types. The Ljung-Box Q-statistics are for auto-correlation test and the test results indicate that the *p*-value of the first 12 lags of the raw series and of the squared series is *0*, which demonstrates significant auto-correlation. The Augmented Dickey-Fuller (ADF) unit root test on the monthly log first-difference freight rate and fleet size series is applied to examine whether the series are stationary. The results indicate that for both ship types the log first-difference of freight rate and fleet size series are stationary.

Table 6-2 Descriptive statistics of logarithmic first difference freight rates and fleet size

	N	*Mean*	*Median*	*S.D.*	*Skewness*	*Kurtosis*	*J-B*	*Q(12)*	*$Q^2(12)$*	*ADF(lags)*
Panel A: Panamax bulker series (January 1973 to April 2008)										
SPR_p	425	0.005	0.012	0.102	-0.819	8.352	554.869	45.035	39.007	-17.345(15)
TCR_p	389	0.009	0.006	0.101	-0.047	9.753	739.206	59.492	66.145	-12.639(1)
FS_p	425	0.006	0.005	0.007	1.999	13.419	2205.670	689.680	523.640	-4.720(16)
Panel B: Capesize bulker series (January 1973 to April 2008)										
SPR_c	425	0.006	0.000	0.100	-0.033	5.678	127.086	38.715	41.594	-15.471(1)
TCR_c	376	0.007	0.004	0.109	0.079	4.713	46.384	57.250	54.012	-13.431(4)
FS_c	425	0.007	0.005	0.010	3.464	23.460	8263.201	230.780	139.910	-8.063(14)

Note

- N is the number of observations.
- S.D. is the standard deviation of the series.
- J-B is the Jaeque-Bera test for normality, distributed as $\chi^2(2)$.
- Q(12) and $Q^2(12)$ are the Ljung-Box Q statistics of the raw series and of the squared series, distributed as $\chi^2(12)$ under the null hypothesis of nonserial correlation with lags up to 12.
- ADF is the Augmented Dickey-Filler test; the appropriate lag lengths (in parentheses) are based on Schwartz Information Criterion (SIC); the 5% critical value is –2.868.
- *SPR*, spot rate; *TCR*, time-charter rate; *FS*, fleet size

6.5 Empirical Results and Discussion

6.5.1 The results of the AR-GARCH models

To analyse the relationship between freight market risk and fleet size, one-step ahead conditional volatility estimates (h_t) of freight rates are constructed through the AR-GARCH model. We first choose the best auto-regression (AR) model for *SPR_p*, *TCR_p*, *SPR_c* and *TCR_c*, determined by Schwarz Information Criterion (SIC). Results show that for *SPR_p* and *TCR_p* series AR(1) is the most suitable lag, and for SPR_c and TCR_c series AR(2) is the most suitable lag. We also apply ARCH LM test (Engle, 1982) to check the autocorrelated conditional heteroskedasticity in the residuals of the AR models. The results show the presence of ARCH effects in freight volatility. We then use the AR-GARCH model to measure the freight rate volatility. The empirical results are reported in Table 6-3. For all four freight rate series, the coefficients of the lagged variance (β) and the lagged error (α) terms are significant at 5% critical levels. Bollerslev (1987) mentioned that the persistence in variance is measured by the sum ($\alpha + \beta$). In our analysis, the results show that the sum ($\alpha + \beta$) is close to, but slightly less than unity, which indicates the persistence in variance for all four freight rate series. We therefore confirm similar findings in the literature (Kavussanos, 1996; Kavussanos, 2003; Adland and Cullinane, 2005; Lu, Marlow and

Wang, 2008) that the volatility of both spot rate and time-charter rate in dry bulk markets are time-varying.

Table 6-3 AR-GARCH model estimates of the conditional volatilities

$$r_t = b_0 + b_1 r_{t-1} + b_2 r_{t-2} + \cdots + b_m r_{t-m} + \varepsilon_t ; \varepsilon_t \sim iid(0, h_t)$$
$$h_t = \omega + \alpha \varepsilon_{t-1}^2 + \beta h_{t-1}$$

	SPR_p (January 1973-April 2008)	*TCR_p (January 1976-April 2008)*	*SPR_c (January 1973-April 2008)*	*TCR_c (January 1977-April 2008)*
b_1	0.174**	0.362**	0.361**	0.480**
Std. Error	0.055	0.053	0.056	0.057
z-Statistic	3.143	6.843	6.433	8.466
Prob.	0.002	0.000	0.000	0.000
b_2			-0.086*	-0.095*
Std. Error			0.049	0.056
z-Statistic			-1.745	-1.704
Prob.			0.081	0.089
ω	0.000	0.000**	0.000**	0.000**
Std. Error	0.000	0.000	0.000	0.000
z-Statistic	1.438	2.945	2.938	2.136
Prob.	0.150	0.003	0.003	0.033
α	0.040*	0.108**	0.136**	0.107**
Std. Error	0.021	0.023	0.038	0.028
z-Statistic	1.930	4.776	3.541	3.766
Prob.	0.054	0.000	0.000	0.000
β	0.896**	0.843**	0.809**	0.852**
Std. Error	0.058	0.030	0.045	0.040
z-Statistic	15.408	28.092	17.837	21.212
Prob.	0.000	0.000	0.000	0.000
$\alpha + \beta$	0.936	0.951	0.945	0.959

Note

- *(**) denotes significance at 10% (5%) critical value levels.
- SPR, spot rate; TCR, time-charter rate

The conditional volatilities for *SPR_p*, *TCR_p*, *SPR_c* and *TCR_c* are presented in Figures 6-1 to 6-4. The figures show time-varying volatility clustering: large changes in volatility occur around certain periods of time, and then small changes in volatility follow, which indicates that volatility tends to stay high during and after periods of large external shocks to the industry. ARCH and GARCH models are employed commonly in modelling volatility of time series exhibiting this characteristic.

Figure 6-1 Panamax dry bulk spot rate volatility (1973:01- 2008:04)

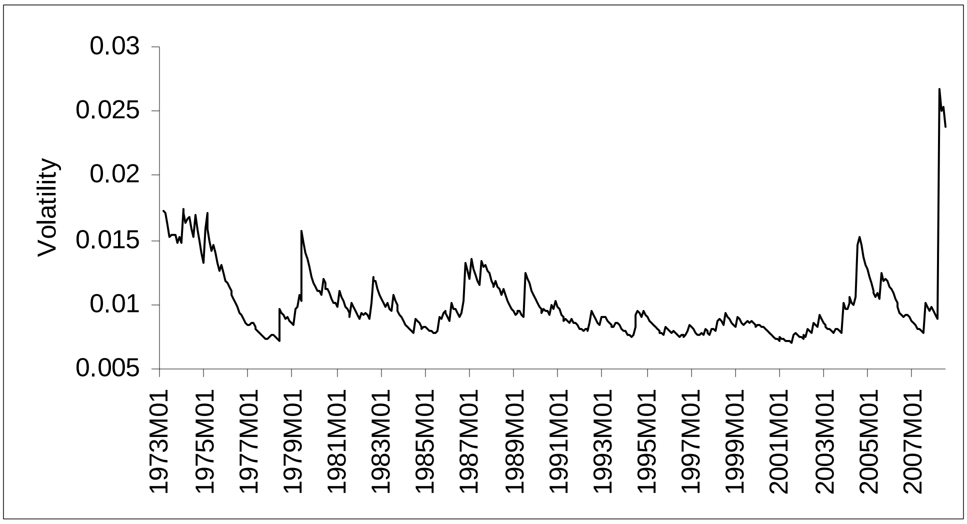


Figure 6-2 Panamax dry bulk time-charter rate volatility (1976:01- 2008:04)

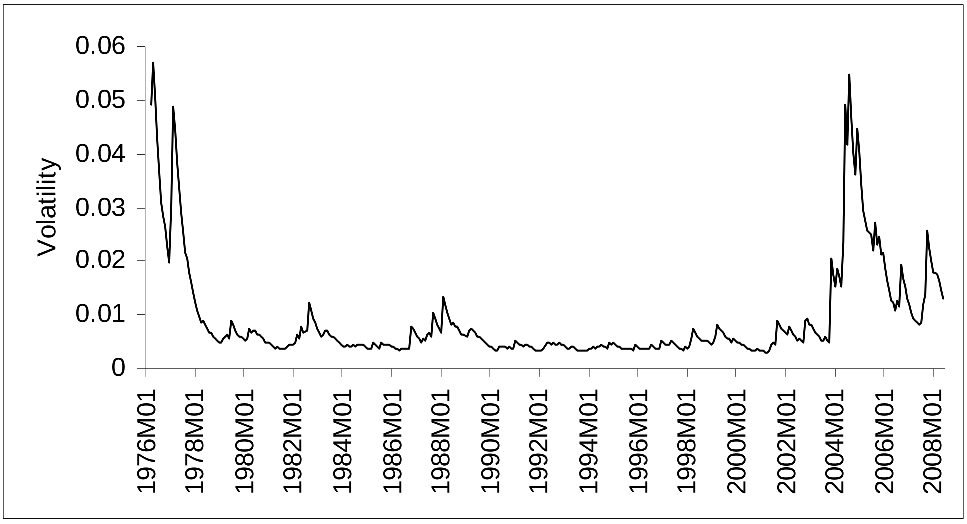


Figure 6-3 Capesize dry bulk spot rate volatility (1973:01- 2008:04)

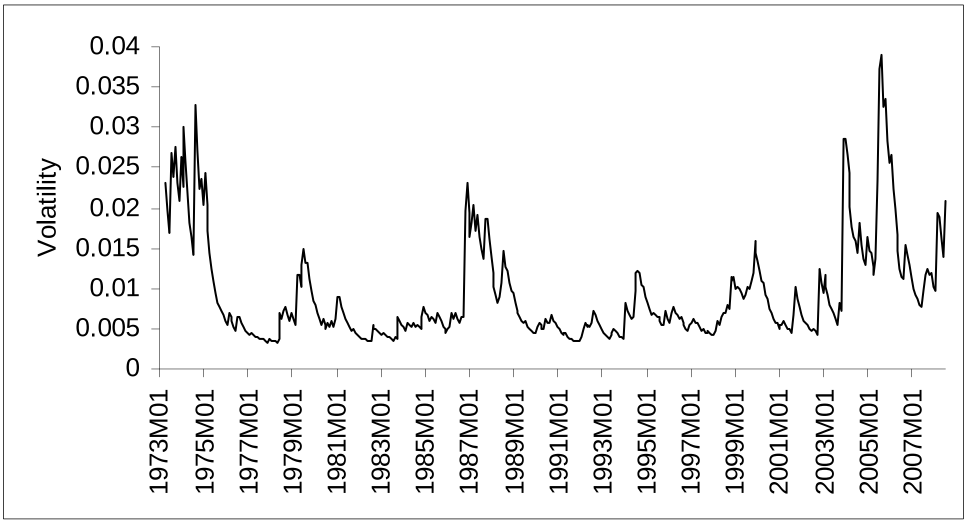
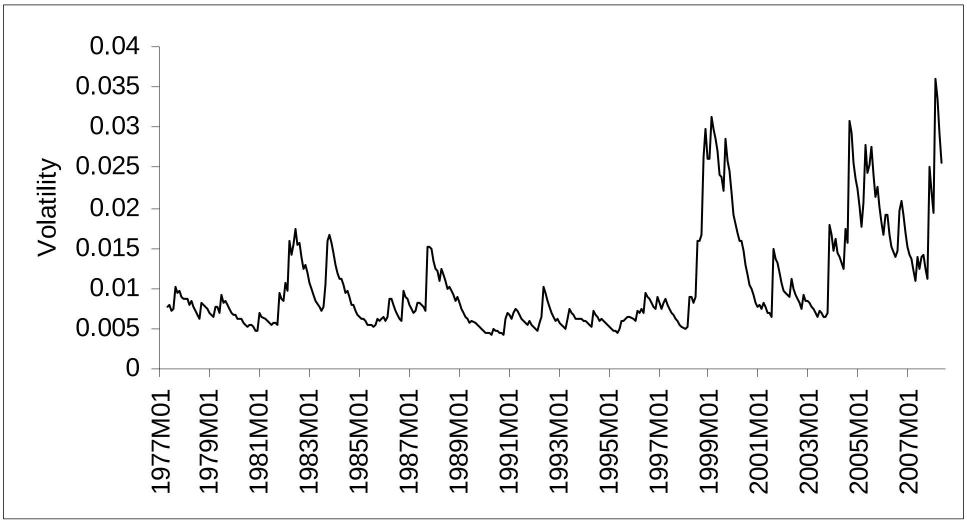


Figure 6-4 Capesize dry bulk time-charter rate volatility (1977:01- 2008:04)



6.5.2 The results of the GMM regressions

With the time-varying freight rate volatilities (h_t) derived from the AR-GARCH models, we analyze the relationship between freight market risk and fleet size. The freight rate volatilities (h_t) are then regressed against FS_t, FS_t^2, FR_t, IP_t, and BP_t as in Eq. 6-1.

Table 6-4 GMM estimates of the relationship between freight rate volatility and fleet size

$$h_t = C_0 + C_1 \ln FS_t + C_2 \ln FS_t^{\ 2} + C_3 \ln FR_t + C_4 \ln IP_t + C_5 \ln BP_t + u_t$$

Explanatory variables	*Panamax Spot (January 1973-April 2008)*	*Panamax Time Charter (January 1976-April 2008)*	*Capesize Spot (January 1973-April 2008)*	*Capesize Time Charter (January 1977-April 2008)*
C_0	0.0675***	0.5709***	0.0929*	0.0752
	(4.099)	(6.4294)	(1.833)	(0.961)
ln*FS*$_t$	−0.0183***	−0.2087***	−0.0404***	−0.0360***
	(−4.542)	(−6.823)	(−4.121)	(−2.749)
ln*FS*$_t^2$	0.0025***	0.0301***	0.0056***	0.0055**
	(4.049)	(6.778)	(3.598)	(2.491)
ln*FR*$_t$	0.0018***	0.0032**	0.0038***	−0.0025*
	(3.081)	(2.033)	(2.789)	(−1.749)
ln*IP*$_t$	−0.0069*	−0.0461***	−0.0022	1.35E-05
	(−1.871)	(−4.102)	(−0.187)	(0.001)
ln*BP*$_t$	−0.0003	−0.0074***	−0.0025**	0.0026
	(−0.425)	(−3.749)	(−1.573)	(1.539)
R^2	0.437	0.491	0.341	0.351
Adj. R^2	0.430	0.485	0.333	0.342
Q(12)	843.70	1285.900	1135.500	1367.200
	[0.000]	[0.000]	[0.000]	[0.000]
$Q^2(12)$	118.950	690.930	523.910	811.200
	[0.000]	[0.000]	[0.000]	[0.000]

Note:

- Figures in parentheses and in squared brackets indicate t-statistics and significance levels, respectively.
- ***, ** and * denotes significance at 1%, 5% and 10% critical value levels, respectively.
- Adj. R^2 is the adjusted R-squares of the regression.
- Q(12) and $Q^2(12)$ are the Ljung-Box Q statistics of the raw series and of the squared series, distributed as $\chi^2(12)$ under the null hypothesis of nonserial correlation with lags up to 12.
- Volatility h_t is defined as the one-step ahead conditional variance of the freight rate, computed from a well-specified AR-GARCH model.
- *FS*, fleet size; *IP*, industrial production; BP, bunker price

The results of the GMM regressions are presented in Table 6-4. The goodness of fit is reasonable with the adjusted R-squared values of 0.333 to 0.485. The adjusted R-squared values of the freight rate volatility regression are considerably high compared to other studies on price volatility (e.g. Devereux and Lane's (2003) study on exchange rate volatility). The Ljung-Box Q-statistics indicate the existence of serial correlation in all regressions, which justifies the use of GMM as a good estimator to deal with autocorrelation and heterogeneity issues.

Previous research considered the modelling of: FR=f(FS, IP, BP) (see, for example, Kavussanos, 1996), with coefficients: ($FS-$ $IP+$, $BP+$). Our research considers the relationship of the volatility h_t and (FS_t, FS_t^2, FR_t, IP_t and BP_t) with coefficients (FS_t-, FS_t^2+, FR_t+, IP_t- and BP_t-).

All the coefficients of $\ln FS$ and $\ln FS^2$ are significant at the 10% level, with $\ln FS$ negatively related to h_t, and $\ln FS^2$ positively related to h_t. This can be interpreted as there being a declining linear effect and an increasing non-linear effect of the change of fleet size on the change of freight volatility. With the increase in the value of $\ln FS$, the non-linear term will take dominant effect over the linear term, which suggests that the increase in the change of the size of the fleet trading in the market leads to an increase in freight rate volatility. The linear and non-linear effects together suggest that the large volatility change is a result of non-linear effect of fleet size. The spot rate volatility of Capesize dry bulk exhibits a stronger reaction to the change of fleet size than Panamax dry bulk, which can be explained since Capesize ships are more vulnerable to market changes due to the trading inflexibility of larger vessels. The time charter rate volatility exhibits the other way around given the inflexibility of time charter itself.

6.6 Concluding Remarks

This chapter provides valuable insights into the current status of freight risk management in the literature. This chapter provides statistically significant evidence that fleet size is a critical determinant of freight volatility and affects it in a nonlinear manner.

This chapter postulates an a priori hypothesis that, in dry bulk shipping markets, the increase in the change of fleet size trading in the market leads to an increase in the change of freight rate volatility. We employ a two-step modelling to examine the relationship between freight market risk and fleet size. We confirm through the AR-ARCH model the similar findings in the literature that the volatilities of both spot rate and time-charter rate in dry bulk markets are time varying, and the freight rate volatility series exhibit clustering characteristics, indicating that volatility tends to stay high during and after periods of large external shocks to the industry. Through the GMM regression, we validate our a priori expectation that the change of fleet size positively affects freight rate volatility. The spot rate volatility of Capesize dry bulk exhibits a stronger reaction to the fleet size as Capesize ships are more vulnerable to market changes due to the trading inflexibility of larger vessels.

This chapter contributes in a general sense to understanding the systematic risk of shipping markets. Given the positive effect of changes in fleet size on freight rate volatility, ship investors should be wary of over-supply in the dry bulk shipping sector, since over-supply of vessels can be translated into both lower freight rate and higher freight market risk.

7 CONCLUSIONS

7.1 Summary of Main Findings

In this thesis, we study the shipbuilding in a wide context from the economic perspective. We raise our three research questions in accordance with the dynamics among freight rate, shipbuilding order and delivery (see Figure 1-6). Firstly, we discuss the lag from freight rate to shipbuilding order. Secondly, we look into the factors influencing the decision of ordering new ships. Thirdly, we study the freight situation after the lag from shipbuilding order to final delivery.

Chapter 4 concerns Research Question 1: the market-driven dynamic relationship between freight rate and shipbuilding price in the dry-bulk shipping sector. We find a strong positive one-way causal mechanism from freight rate to shipbuilding price. The time lags from freight rate to shipbuilding price are approximately three to six months (see Figure 4-2). This chapter concludes the interdependence of two shipping markets, where the sea freight market trades cargo-carrying service and the shipbuilding market trades new ships. Our results indicate that the investment behaviour in physical assets for future service capacity is encouraged by a strong service market. The results further imply that market inefficiency is expected across markets, as the service market is more sensitive to the market changes than the asset market, freight market is in the lead in price discovery, since new information tends to be processed more rapidly in the freight market than in the shipbuilding market.

Chapter 5 concerns Research Question 2: the determinants of shipbuilding activities. Through pooled panel data analysis, world fleet size, world trade volume, and spot freight rate are found to be the three most important factors to the amount of shipbuilding orders. The spot freight level factor contributes to the ship investment decision more than the market supply and demand factors (fleet size and trade volume). Shipbuilding price, secondhand ship price and investment incentives are proved to have no linkage to the amount of shipbuilding orders. With regard to location factor and cluster effect, we find that location advantage and cluster effect are of great help to attracting more shipbuilding orders. Our finding implies the important role of freight market to ship investment decision. Only if the freight market became prosperous again could we expect a prosperous shipbuilding market. Our finding also shows the strong cluster effect of Asian countries in the shipbuilding sector, namely Japan, South Korea and China.

Chapter 6 concerns Research Question 3: the impact of fleet size on freight volatility. Our results prove that fleet size is a critical determinant of freight volatility and affects it in a nonlinear manner. We confirm through the AR-ARCH model that the volatilities of both spot rate and time-charter rate in dry bulk markets are time varying, and the freight rate volatility series exhibit clustering characteristics, indicating that volatility tends to stay high during and after periods of large external shocks to the industry. Through GMM model we prove that the increase in the change of fleet size trading in the market leads to an increase in the change of freight rate volatility. The spot rate volatility of Capesize dry bulk exhibits a stronger reaction to the fleet size as Capesize ships are more vulnerable to market changes due to the trading inflexibility of larger vessels. Given the positive effect of changes in fleet size on freight rate volatility, ship investors should be wary of over-supply in the dry bulk shipping sector, since over-supply of vessels can be translated into both lower freight rate and higher freight market risk.

7.2 Academic Implications

The contributions of this study are two-fold. Firstly, we fill in a gap in the maritime economics literature. Through changing the research focus on maritime economics from the freight market to the shipbuilding market, we have performed a series of analyses of the role of shipbuilding in the global shipping. Secondly, we raise a new research angel in shipping economics through specifically examining the factor of ‘time lag’ between different shipping segments. By analysing the dynamics among freight rate, shipbuilding order and delivery, we have found shipbuilding variables do not interact with other economic variables in a static way. Time lag issues need to be largely considered in shipping economic studies.

Our analysis in Chapters 4 and 5 reveals that shipbuilding market is a derived market, as it reacts less efficiently to new information, shipbuilding prices change alongside with freight rates, and shipbuilding activities largely depend on the operating environment of the freight market. However, through Chapter 6, we found what happens in shipbuilding market influences back freight market profoundly. While the investment behaviour in physical assets (new ships) for future service capacity is encouraged by a strong service market (freight market), large amount of ship deliveries due to habitual massive shipbuilding ordering can cause both lower freight rate and higher freight market risk. The dynamics among freight rate, shipbuilding order and delivery act in a cyclical manner. By adopting modern econometric analytical techniques rather than pure modelling, our study contributes to the maritime economics literature by providing a comprehensive economic analysis of shipbuilding.

7.3 Policy Implications

From the above discussion, we highlight three key policy implications on the shipbuilding activities.

(1) Shipbuilding industry: freight-driven industry

Of the three basic variables, the spot freight level factor turns out to contribute more to the ship investment decision than the market supply and demand factors (fleet size and trade volume). This finding indicates that the shipbuilding industry is highly freight driven. Shipowners care about the future payoff of the ships in freight market when they decide whether to invest new ships. The shipbuilding market will not recover until the freight market becomes prosperous again.

(2) Investment incentives: do they really work?

Shipbuilding industry has been known as an industry enjoying enormous investment incentives from the government. However, as our results show, investment incentives do not work as what policy makers expect, a large FDI volume in transportation in the host country does not necessarily lead to more investment on new ships. Any incentive to shipbuilding investment is unlikely to work as the governments expect. When the government makes policies for shipbuilding industry, they might need to consider other ways to encourage the freight industry instead.

(3) Cluster effect: the new shipbuilding centre

The interaction effects between shipbuilding cluster and fleet size, trade volume and freight rate in our models show that cluster effect is of great help to attracting more shipbuilding orders. One explanation is the economies of scale for shipbuilding, and another is that Japan, South Korea and China have great location advantage of being a large consumers' market for maritime transportation. It is a fact that the shipbuilding centre is shifting from the West to the East. Our robustness test especially reveals China's new major position in shipbuilding sector. Traditional European shipbuilding countries need to focus on high-value added segments in shipbuilding industry.

7.4 Limitations of This Study

Due to the limitation of empirical study and the unavailability of data, we shall discuss a number of limitations of this study.

Firstly, we have chosen dry bulk market as our research target. The dry bulk shipping market is considered close to perfect competition, since shipowners and charterers are too numerous and relatively small to influence the market price substantially. Therefore, we only study the market-driven dynamics of the dry-bulk shipping sector in this thesis. The results might not be applicable to other shipping markets such as container market.

Secondly, we have focused mostly on shipbuilding and freight markets since they are the two shipping markets causing major cash flows. Other shipping markets such as second hand and demolition markets also interact on shipbuilding market. We only considered in Chapter 5 the effect of second hand ship price on ship investment decisions.

Thirdly, due to the unavailability of the data, the data in Chapter 5 were collected on an annual basis, the analysis results might not reflect the subtle changes of the variables. Another limitation of the data concerns the duration. Since the financial crisis started around mid-2008, the shipping world has gone through tremendous changes. However, our data has not fully covered this period of time. Our results might not be able to represent the situation of this period. Robustness test will be needed when we prolong the data duration.

Finally, the selection of models in this study is limited to our understanding in shipping. All the models adopted in this study are well developed ones, we have chosen most models for the reason that they have been proved to be efficient or widely used in similar studies. For example, we applied AR-GARCH to model the conditional volatility of freight rate, since it has been proved to adequately fit shipping related time series (Batchelor, Alizadeh and Visvikis, 2005). Other models, such as ARMA-GARCH, might also fit the data.

7.5 Suggestions for Further Research

We have performed a comprehensive economic analysis of shipbuilding in this thesis. However, we have focused on its interdependence with freight market most. We have provided a basis for future economic research on shipbuilding. Future research may be carried out to examine the role of shipbuilding by involving more of its interactions with second hand and demolition markets.

We have considered the shipbuilding market to be the capital market of new ships, and freight market to be the service market. In the service market, we have chose only freight rates (spot rate and time charter rate) to discuss, future research can extend the prices to freight derivatives, such as Forward Freight Agreement (FFA).

As mentioned, the shipping world has gone through tremendous changes since the financial crisis in mid-2008, future research may take the cancellation of shipbuilding orders, the change of interest rate and currency rate into consideration, so as to understand the shipbuilding behaviour under special situation.

For our third topic, further research is needed to compare systematic risks across different markets and to explore their size effects.

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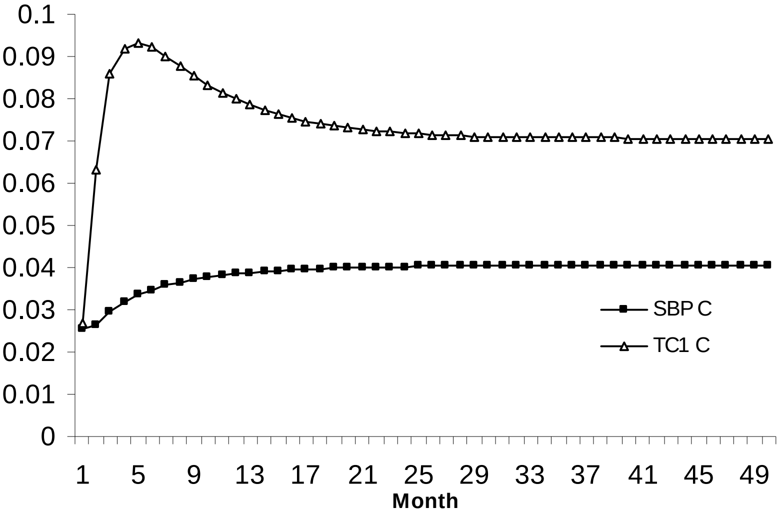
APPENDICES

APPENDIX 4A Convention factor of BHI and BSI

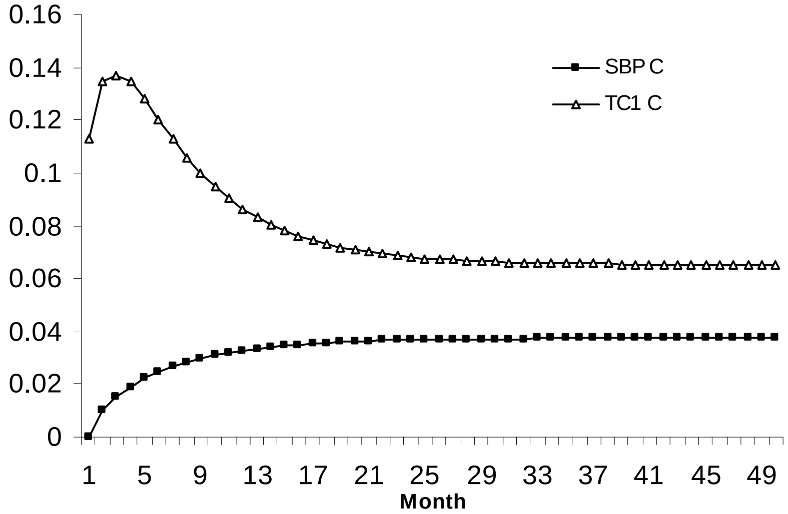
It is worth noting that the Baltic Handymax Index (*BHI*) was replaced by the Baltic Supramax Index (*BSI*) on 23 December 2005. During the transition period, there was a dual reporting period of both the *BHI* and *BSI* from 1 July 2005 to 23 December 2005. In this study, we use the following Conversion Factor suggested by the **International Maritime Exchange** to convert BSI to BHI after 23 December 2005:

$$Conversion\ \ Factor = \left.\frac{Average\ of\ \ BHI}{Average\ of\ \ BSI}\right|_{During\ the\ dual\ reporting\ \ period\ (1\ Jul\ to\ 23\ Dec\ 2005)}$$

APPENDIX 4B Generalized Impulse Responses of SBP_C & $TC1_C$: Capesize ships

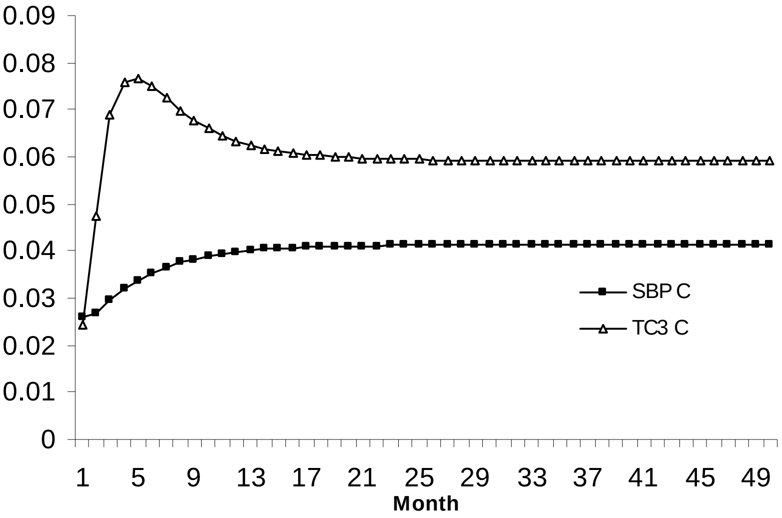


In the equation for SBP_C

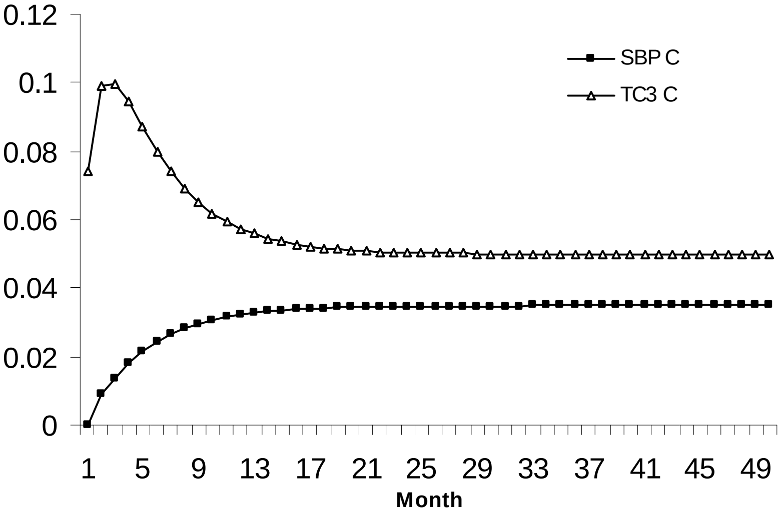


In the equation for $TC1_C$

APPENDIX 4C Generalized Impulse Responses of SBP_C & $TC3_C$: Capesize ships



In the equation for SBP_C



In the equation for $TC3_C$

APPENDIX 4D Granger causality test: Capesize, Panamax and Handymax ships (1998:05 – 2007:12)

Walt tests	*H0:* $b_{SBP,i} = 0$	*H0:* $a_{BDI,i} = 0$	*Walt tests*	*H0:* $b_{SBP,i} = 0$	*H0:* $a_{TC1,i} = 0$	*Walt tests*	*H0:* $b_{SBP,i} = 0$	*H0:* $a_{TC3,i} = 0$
Capesize Bulker series (1999:03-2007:12)								
	ΔBDI_{C_t}	ΔSBP_{C_t}		$\Delta TC1_{C_t}$	ΔSBP_{C_t}		$\Delta TC3_{C_t}$	ΔSBP_{C_t}
	6.461*	4.642		7.326*	5.467		4.483	3.832
	[0.040]	[0.098]		[0.026]	[0.065]		[0.106]	[0.147]
Panamax Bulker series (1998:05-2007:12)								
	ΔBDI_{P_t}	ΔSBP_{P_t}		$\Delta TC1_{P_t}$	ΔSBP_{P_t}		$\Delta TC3_{P_t}$	ΔSBP_{P_t}
	7.899*	2.228		19.581**	1.858		46.467**	2.339
	[0.019]	[0.328]		[0.000]	[0.395]		[0.000]	[0.311]
Handymax Bulker series (2000:09-2007:12)								
	ΔBDI_{H_t}	ΔSBP_{H_t}		$\Delta TC1_{H_t}$	ΔSBP_{H_t}		$\Delta TC3_{H_t}$	ΔSBP_{H_t}
	9.653**	0.147		18.888**	1.741		18.935**	3.961
	[0.002]	[0.702]		[0.000]	[0.419]		[0.000]	[0.138]

Note:

- Figures in [ ] stands for P-values.
- The lag length of the VECM model is determined by Schwarz Info Criterion (SIC).
- *(**) denotes rejection of the null hypotheses at 5% (1%) critical value levels.

APPENDIX 5A Pooled OLS estimations of the amount of shipbuilding order contracts models (1997-2001)

Variables		***Models***	
Dep.Var. **CONTRACT$_t$**	**No. Obs.** **75**	**No. Obs.** **75**	**No. Obs.** **75**
CONTRACT$_{t-1}$	0.538**	0.546**	0.540**
	(5.315)	(5.453)	(5.309)
FS	-11.404*	-11.565*	-11.368*
	(-1.931)	(-1.955)	(-1.921)
TRADE	0.285	0.308*	0.287
	(1.503)	(1.645)	(1.514)
FREIGHT	1.674**	1.652**	1.643**
	(2.290)	(2.252)	(2.240)
TS	0.763*	0.859*	0.768*
	(1.679)	(1.922)	(1.685)
CLUSTER* FS	0.235** (2.609)		
CLUSTER* TRADE		0.476** (2.556)	
CLUSTER* FREIGHT			0.163** (2.560)
GDPPC	-0.160	-0.237	-0.165
	(-0.693)	(-1.085)	(-0.712)
Constant	64.265*	65.840*	64.328*
	(1.736)	(1.776)	(1.735)
Adjusted *R*-squared	0.745	0.744	0.744
F-statistic	31.932	31.778	31.791

Notes: *t*-statistics in parentheses
** indicates significance at the 5% level
* indicates significance at the 10% level

APPENDIX 5B Pooled OLS estimations of the amount of shipbuilding order contracts models (2002-2008)

Variables	***Models***		
Dep.Var. CONTRACT$_t$	**No. Obs. 87**	**No. Obs. 87**	**No. Obs. 87**
CONTRACT$_{t-1}$	0.357**	0.386**	0.361**
	(3.360)	(3.664)	(3.377)
FS	-0.618	-0.984	-0.561
	(-0.260)	(-411)	(-0.235)
TRADE	0.292	0.267	0.293
	(1.516)	(1.358)	(1.520)
FREIGHT	0.996**	0.960*	0.944*
	(2.027)	(1.929)	(1.913)
TS	0.774*	0.864*	0.775*
	(1.757)	(1.954)	(1.754)
CLUSTER* FS	0.386**		
	(4.153)		
CLUSTER* TRADE		0.666**	
		(3.872)	
CLUSTER* FREIGHT			0.260**
			(4.073)
GDPPC	-0.330*	-0.318*	-0.333*
	(-1.829)	(-1.718)	(-1.836)
Constant	2.125	4.314	2.232
	(0.160)	(0.322)	(0.167)
Adjusted *R*-squared	0.755	0.749	0.753
F-statistic	38.803	37.629	38.460

Notes: *t*-statistics in parentheses
** indicates significance at the 5% level
* indicates significance at the 10% level

APPENDIX 5C Pooled OLS estimations with China, South Korea and Japan dummies

Dependent Variable: $CONTRACT_t$
Method: Pooled Least Squares
Sample (adjusted): 1997 2007
Total pool (unbalanced) observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.519	8.716	1.551	0.123
$CONTRACT_{t-1}$	0.428	0.074	5.811	0.000
FS	-2.549	1.702	-1.498	0.136
TRADE	0.380	0.141	2.704	0.008
FREIGHT	1.108	0.395	2.806	0.006
TS	0.880	0.312	2.815	0.006
JAPAN*FS	0.348	0.076	4.568	0.000
KOREA*FS	0.309	0.080	3.861	0.000
CHINA*FS	0.203	0.095	2.133	0.035
GDPPC	-0.400	0.174	-2.296	0.023
R-squared	0.768	F-statistic		56.013

APPENDIX 5D Pooled OLS estimations with China, South Korea and Japan dummies

Dependent Variable: $CONTRACT_t$
Method: Pooled Least Squares
Sample (adjusted): 1997 2007
Total pool (unbalanced) observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	15.710	8.678	1.810	0.072
$CONTRACT_{t-1}$	0.429	0.074	5.829	0.000
FS	-2.817	1.699	-1.658	0.099
TRADE	0.367	0.142	2.585	0.011
FREIGHT	1.075	0.395	2.722	0.007
TS	0.825	0.317	2.605	0.010
JAPAN*TRADE	0.639	0.139	4.588	0.000
KOREA* TRADE	0.754	0.194	3.891	0.000
CHINA* TRADE	0.402	0.180	2.225	0.028
GDPPC	-0.387	0.175	-2.215	0.028
R-squared	0.768	F-statistic		56.059

APPENDIX 5E Pooled OLS estimations with China, South Korea and Japan dummies

Dependent Variable: $CONTRACT_t$
Method: Pooled Least Squares
Sample (adjusted): 1997 2007
Total pool (unbalanced) observations: 162

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	13.586	8.731	1.556	0.122
$CONTRACT_{t-1}$	0.429	0.074	5.804	0.000
FS	-2.501	1.706	-1.465	0.145
TRADE	0.382	0.141	2.707	0.008
FREIGHT	1.069	0.396	2.699	0.008
TS	0.877	0.314	2.797	0.006
JAPAN*FREIGHT	0.240	0.053	4.525	0.000
KOREA* FREIGHT	0.212	0.056	3.813	0.000
CHINA* FREIGHT	0.138	0.066	2.089	0.038
GDPPC	-0.403	0.175	-2.302	0.023
R-squared	0.768	F-statistic		55.761