SHIPPING MARKET ECONOMICS: KNOWLEDGE EVOLUTION, SECOND-HAND SHIP PRICE AND FREIGHT RATE

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Shipping Market Economics: Knowledge Evolution, Second-hand Ship Price and Freight Rate

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A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

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CERTIFICATE OF ORIGINALITY

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______________________________ (Signed)

WenHao Peng

Abstract

This thesis is composed of three studies focusing on shipping market economics. The first study collects 179 papers from 38 academic journals related to shipping market economics. Through a bibliometric analysis on the author collaboration, evolution of research topics and methods, the research in shipping market economics is found to transfer from technique-driven to idea-driven. The results show the number of author's citations is positively related to his/her centrality score in social network. The findings provide empirical evidences on the effect of author collaboration. The research topics in shipping market economics are becoming convergent and organized, while the research methodologies are becoming diverse. The study identifies some underdeveloped field in shipping market economics to be further investigated. All these challenges should be viewed as an opportunity: An opportunity to contribute to the understanding of shipping market economics, an opportunity to develop some underdeveloped topics; an opportunity to apply new ideas and concepts into the shipping market economics.

The second study investigates second-hand ship price in shipping investment incorporating seller buyer domicile effect. Besides ship specific factors and market conditions, the domicile effect is incorporated into a fixed effect model. The results confirms the importance of investor domicile effects and illustrates that investor domicile represents an appropriate proxy for the culture traits of investors as well as for the impact of domicile economic conditions on funding costs and market expectations. The results put emphasis on the counterpart domicile selection during the negotiation stage.

The third study addresses the seasonality issue in the freight rate market. The impact of the China effect on dry bulk commodity market is considered. Through comparing different seasonality patterns before and after the China effect, the results demonstrate that the China effect has changed the seasonal patterns of freight rate dramatically. The seasonal effect of October becomes reverse which can be potentially attributed to China's National Day and import-export habit. The results are helpful for shippers, engaged in major dry bulk commodity transport, to adjust their capacity using the seasonal movement of freight rate.

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Last but not least, I would like to express my deepest gratitude to my parents, for their everlasting love and trust. I also owe my gratitude to my colleagues. They are my best friends in my PhD life and provide much help in my academic path.

Best wishes to all the peoples in my PhD life. The unforgettable time with you is the biggest treasure in my life.

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List of Abbreviations

AIS: Automatic Identification System

ARIMA: Autoregressive Integrated Moving Average Model

BCI: Baltic Capesize Index

BDI: Baltic Dry Index

BFI: Baltic Freight Index

BHMI: Baltic Handymax Index

BIFFEX: Baltic International Freight Futures Exchange

BPI: Baltic Panamax Index

BRICS: Brazil, Russia, India, China and South Africa

CUSUM: Cumulative SUM Control Chart

DWT: Dead Weight Tonnage

FFA: Freight Forward Agreement

GARCH: Generalized Autoregressive Conditional Heteroskedasticity Model

IMO: International Maritime Organization

LNG: Liquefied natural gas

LPG: Liquefied petroleum gas

OLS: Ordinary Least Squares

SARIMA: Seasonal Autoregressive Integrated Moving Average

SIN: Shipping Intelligence Network

STL: Seasonal and Trend Decomposition using Loess

UNCTAD: United Nations Conference on Trade and Development

VAR: Vector Autoregressive Model

VECM: Vector Error Correction Model

VLCC: Very Large Crude Carrier

WTO: World Trade Organization

Chapter 1. Introduction

A 150,000 DWT (Dead Weight Tonnage) Capesize dry bulk carrier is sailing on the sea. She loads the iron ore from the port of Tubarao, the largest iron ore export port in Brazil, and she sails via the Atlantic Ocean and the Indian Ocean towards the port of Qingdao. This ship is operated by a ship charterer and the charterer leases the ship from a ship owner based on a one-year time charter contract. The daily charter expense is 6,781$/day. The cargo owner pays the ship operator the voyage charter fee at 8.00$/tonne. The ship was built 10 years ago in a Japanese ship build yard and delivered to her first owner. After sailing for 5 years, the ship was sold to her current ship owner at the price of 27 million dollars. The current ship owner plans to lay-up this ship to reduce the oversupply of fleet capacities. In the near future, this ship will be resold in the second-hand ship market or demolished in the demolition market.

The above story (based on the data in Shipping Intelligence Network 2008) describes the whole picture of a typical life cycle of a ship and how the marine transport is operated in shipping practice. Some issues arise from the story, such as why choose Capesize to transport iron ore; what decides the charter expense and voyage charter fee; and what influences the ship price in vessel transaction. To address those issues, the concept "Shipping Market Economics" is introduced. This chapter illustrates the composition of shipping markets and introduces the economic motivations and behaviors in shipping markets, which is also known as Maritime Economics.

1.1 Research Background

Maritime transport has a history of over 5,000 years (Stopford, 2009). The development of maritime transport mainly associates with the increase in productivity. The division of labor and industrial revolution enable human beings to produce additional goods for trading. Then people need to seek for markets to sell their products. The question is how to transport their goods to other regions. Compared with land transport, maritime transport has higher efficiency in both capacity and cost. As a result, maritime transport becomes the highway of economic development.

Nowadays goods transported over ocean are various. Based on corresponding physical and commercial properties of transported goods, different types of ships are utilized to carry them. There are basically three types of ships widely used worldwide. Tankers carry the wet cargoes to drive the world go round. The wet cargoes include crude oil, petroleum products such as diesel oil and some liquefied gas like LNG (Liquefied Natural Gas) and LPG (Liquefied Petroleum Gas). Dry bulk carriers transport the raw materials and cargoes from industrial and agricultural production. The dry bulk cargos include major bulks: iron ore, coal and grains; and minor bulks such as sugar, fertilizers and minerals. Container ships also transport dry cargoes, but in a different way compared to dry bulk carriers. Dry cargoes on container ships are packed into many standardized containers.

The growth of seaborne trade is closely linked to the world economic growth. According to UNCTAD (2019), the global seaborne trade volume has reached 11 billion tons by 2018, within which containerized trade accounts for 17% , major dry bulk commodities (iron ore, coal and grains) account for 28% and crude oil, petroleum products and gas trade account for 29%. The global investment, manufacturing activity and merchandise trade drive the demand for shipping services.

Maritime transport is a capital intensive industry. The capital cost and running cost of a ship could easily exceed 10 million dollars per annum. For example, the annual purchase cost of a 10-year-old Capesize bulk carrier in 2005 was 6.4 million dollars. After purchasing the ship, ship owners or charters need to operate the ship to earn revenue. The voyage cost which includes bunker cost, port charge and canal dues can reach 6 million dollars per annum. At the same time, the operating cost that is composed of various onboard costs accounts for 2.1 million dollars per annum. In addition, ships need to take periodic maintenance and pay cargo-handling cost. All these costs bring challenges to the shipping companies' capability of financial management.

However, maritime transport is never a business without risk. The revenue of shipping companies mainly comes from freight rate of operating ships. The freight rate is determined by the demand for and supply of shipping services. Any shock of world economy would influence the demand regionally or globally. The individual decision to lay-up ships and over ordering of shipping capacity are changing the supply side. Therefore, in the short term, freight rate is always fluctuating and shows a high volatility. Further, the market price of ships can also be highly volatile. For example as shown in Figure 1-1, during the financial crisis, the price of a 5-year second-hand dry bulk Capesize ship dropped from 134 million USD to 48 million USD in only two months. The dramatic change in ship price would distort the market sentiment and bring much uncertainty to individual decisions. In 2016, Hanjin Shipping company, the largest container shipping company in South Korea and one of the top ten container carriers, fell into bankruptcy due to the continuous downturn of container shipping industry.

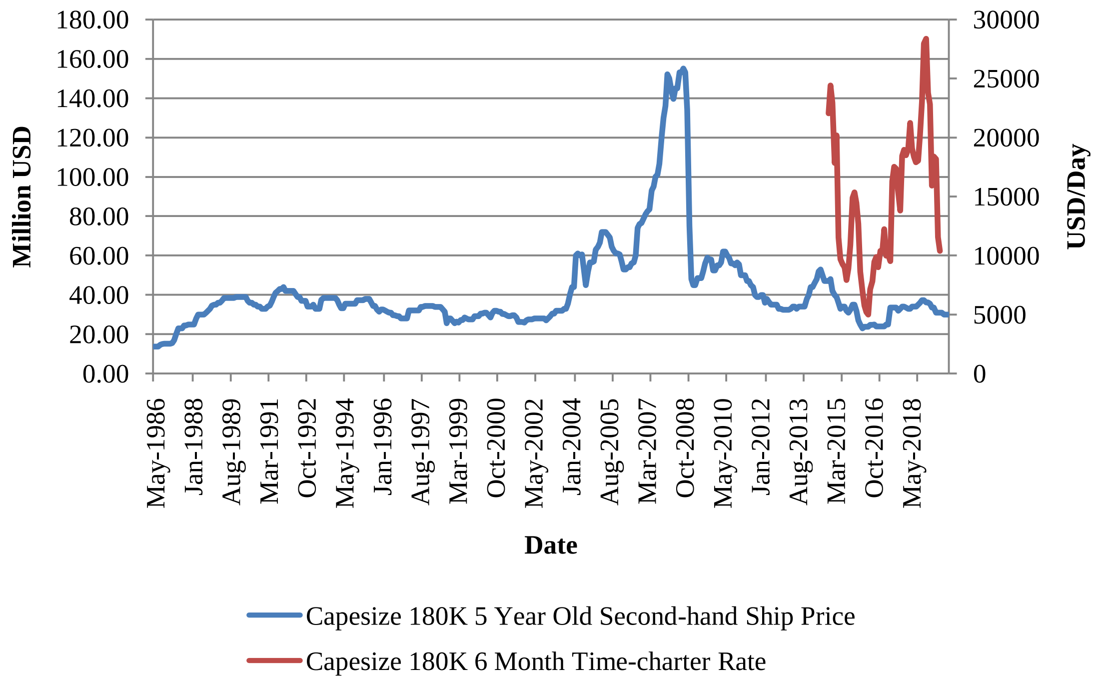


Figure 1-1. Second-hand ship price and 6 month time-charter rate for 180K dwt Capesize dry bulk carrier

Therefore, it is essential to evaluate the volatility of shipping markets and improve methods to hedge risks in maritime transport, which are of interest to both maritime transport participants and academies. This will advance the development of maritime economics.

1.2 Research Scope of this Thesis and Thesis Motivations

1.2.1 Research scope of this thesis

Heaver (1993) defined maritime economics as "the application of the tools of economic analysis to understand and improve resource allocation to and within the maritime sector". From this definition, we can understand the fundamental tool applied in maritime economics, i.e. economic analysis. Economic analysis is popular in firm management and project operation where limited resource need to be utilized wisely. While "resource" in maritime sector covers many aspects and is closely related to the topics investigated. In terms of research topics in maritime sector, Shi and Li (2017) provided a summary of topics in maritime sector during 2000-2014. Their topic summary is shown in Figure 1-2. The research interests in shipping sector cover a variety of disciplines, such as policy, labor, security, sustainability, supply chains, economics and operations management. If one or multiple of the following topics are investigated with economic analysis, these researches can be categorized into maritime economics. Therefore, maritime economics is a wide subject including various topics and across miscellaneous disciplines.

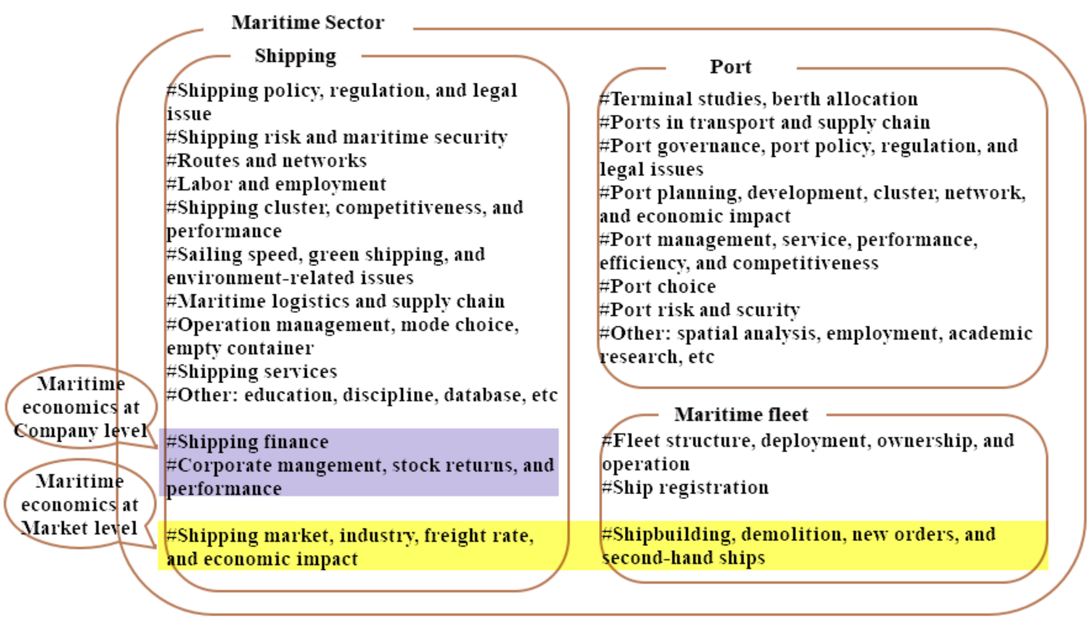


Figure 1-2. Research topics in maritime sector

Note: Author's own figure based on the categorization by Shi and Li (2017).

Investigating maritime economics, such an immense subject, is not an easy task. In this thesis, this research only selects part of topics in maritime economics. The chosen topics are marked yellow in Figure 1-2, which is called maritime economics at market level. The topics in this field are related to four shipping markets and decide the availability of the most important resource in shipping industry, namely vessels. For simplicity and distinctiveness, this research uses the "shipping market economics" to represent those topics. The research scope of this thesis is thus defined as shipping market economics.

Shipping market economics involves the study of organization of shipping markets as well as the characteristics of market mechanism. Specifically it focuses on supply, demand and freight rate theory and how it works within the four shipping markets. Research interests in shipping market economics are to quantify those market mechanisms through the applications of economic tools, such as econometrics and economic modelling.

1.2.2 Thesis motivations

The reasons to select this scope are two folds. First, shipping market economics is the foundation for recognizing and investigating the shipping market, other topics should all be based on a clearer understanding of shipping market economics. At the practical level, shipping market participants are always sensitive to the market conditions because any future disruption to the market would significantly influence their investment revenues. The advancement of Shipping market economics helps to understand the mechanism and causality of various market indexes, thus providing reliable estimates of future market conditions as well as hedging strategies. For every maritime economist, shipping market economics is the basic and also the most important lesson before further investigating the shipping market.

Second, a variety of standardized data facilitates the research of shipping market economics. Since the first introduction of BFI in 1985, diverse market indexes, such as BCI (Baltic Capesize Index), BPI (Baltic Panamax Index), BHMI (Baltic Handymax Index), BDI (Baltic Dry Index), Freight futures and FFA (Freight Forward Agreement), together with time series data published by big shipping companies, like Clarksons and Lloyd's List, stimulate the applications of economic analysis in shipping market. In recent years, with the development of data collection techniques, more micro-level data, such as AIS (Automatic Identification System), become available to researchers and thus bring new research topics. As a consequence, the research topics and methods in shipping market economics should be potentially influenced by their data sources.

An investigation of shipping market economics is supposed to bring insights into the development of this discipline and shed light on future research.

In the next section, shipping market economics and its research objectives are introduced specifically. As a complementation, the market economics at the company level (marked purple in Figure 1-2) is also mentioned.

1.3 Maritime Economics at Market and Company levels

As shipping market participants, people are always faced with two practical questions: 1. Which shipping market section to investigate; 2. How to balance their cost and revenue in investment practice. Those two research questions are explained from the perspective of maritime economics at the market and company levels.

1.3.1 Maritime economics at market level

Maritime economics at the market level can also be called as shipping market economics. The research interests in this field are focused on market mechanism like market organization and practical issues in shipping market operation. Data adopted in this field are often market index, such as new building price, freight rate and shipping derivatives. These indexes provide a general description of overall market conditions and guidance to individual investment in shipping market. However, with the development of shipping industry, more and more micro-level data, such as AIS data, are applied. No matter whether the data is macro- or micro-level, the objective is always to solve macro-level issues.

Shipping market, regardless of which types of ship, can be divided into four sectors, that is Ship building market, Sale and purchase market, Freight market and Demolition market. Those four markets are closely related and involve the whole life of a ship. The interaction among four shipping markets is illustrated in Figure 1-3. It can be observed that the biggest difference between freight market and other three markets is the commodity characteristics. In other three markets, the main trading commodity is the ship. While in freight market, the main trading good is the service, i.e. the transportation of certain cargoes. Because service cannot be stored nor traded more than once, the freight market comes with more risks. As a result, derivatives market is created to hedge risks in freight market, such as FFA and freight futures. Those four markets are linked through cash flow within shipping companies.

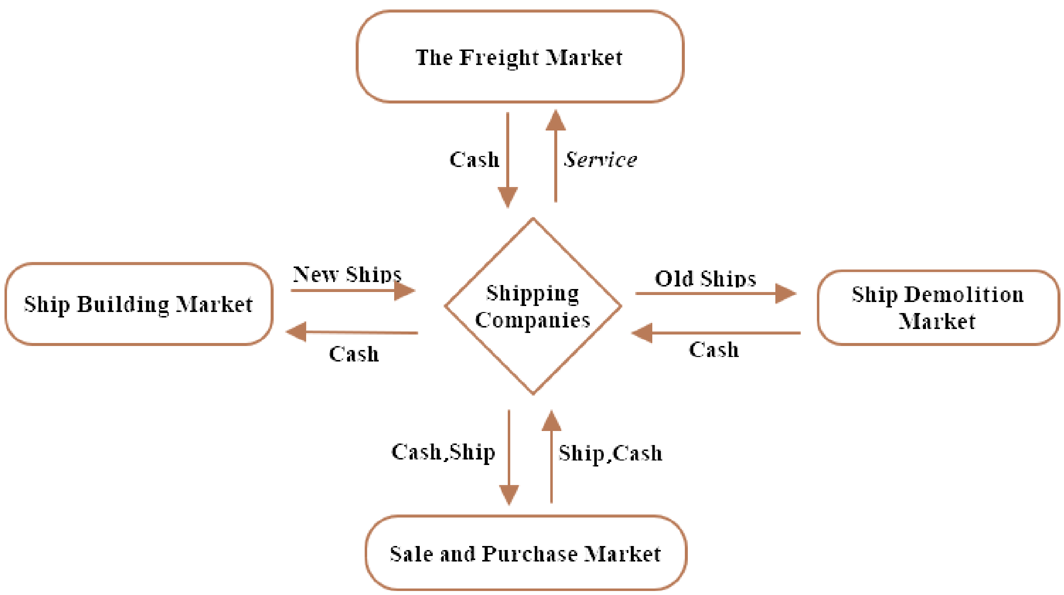


Figure 1-3. Interactions among four shipping markets

The fundamental rule regulating four shipping markets is the supply and demand theory. The prices of vessels and freight rate are decided through the match of supply and demand. Factors influencing the supply and demand in shipping market is miscellaneous. Stopford (2009) selected the most important ten factors. On the supply side, five factors include world fleet, fleet productivity, shipbuilding production, scrapping and losses and freight revenue. World fleet refers to how many vessels and capacities are available in current market. At the same time, not all those capacities are utilized. The ratio of utilization of fleet capacity is called fleet productivity. Shipbuilding production provides new capacity to current fleet, but with some delay between order and delivery. The world fleet can also decrease due to the demolition of old vessels or some accidents. The above four factors are direct influencing factors deciding the fleet capacity. While freight revenue is the indirect but ultimate influencing factor. The decision to build more ships, lay up or demolish ships is all based on freight revenue. On the demand side, five influencing factors are the world economy, seaborne commodity trades, average haul, random shocks and transport costs. World economy is undoubtedly the most important influencing factor, since the demand for sea transport is mostly generated by world economy. The changes in ship demand can be caused by business cycle and trade development cycle in world economy. Seaborne commodity trades can influence the demand through short-term and long-term volatility. Short-term volatility is caused by seasonality of certain cargoes, while long-term volatility is caused by changes in the supply or demand equilibrium of certain commodities. Average haul refers to the tonnage of cargo shipped, multiplied by the average distance over which it is shipped. Average haul directly indicates the demand for ships from certain commodities. Changes of average haul of commodities are the consequence of balance of long-haul and short-haul suppliers. Random shocks refer mostly to the economic shocks worldwide and political events. Finally, the transport cost is also an important consideration in creating new seaborne demand. Thanks to the development of bigger ships and higher efficiency in ship operation, transport cost is getting lower. The ten factors in supply and demand are illustrated in Figure 1-4.

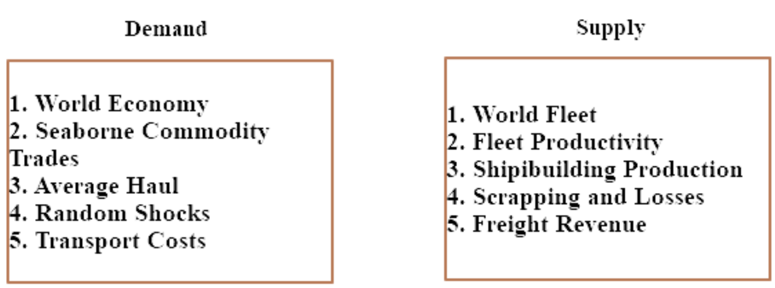


Figure 1-4. Factors influencing Demand and Supply of shipping services

1.3.2 Maritime economics at company level

Information at the market level maritime economics are useful to government policy and individual investment guidance. It can provide a general framework of the whole industry. But for a certain investor, the most important concern is the money issue, that is cash flow. Maritime economics at the company level is focused on individual cash flow and risk management.

In the concept of cash flow, cost and revenue are the basic input and output of an shipping company. In the cost side, the capital cost, i.e. purchase of ships, is also a unique feature in shipping industry. Because the value of a ship can easily reach 40 million USD for a dry bulk carrier and over 100 million USD for a container ship. Private equity can barely afford such big amount. According to Kavussanos et al. (2016), bank loan accounts for 79% of the capital source of shipping companies in 2015. As a result, the debt and interest become an important part in cash flow management in shipping companies.

Capital cost usually takes three forms (Stopford 2009). First, when ship owner orders a new ship, he needs to pay deposit and installment payments to the shipyard. Second, if the purchase funding comes from banks or equity investors, ship owner will bear a periodic payment to them. Third, there will be an income from selling or scraping ships. But this income usually takes time and suffers from depreciation. Ship owners need to pay attention to those costs in different time points and adjust his cash flow wisely.

Except the capital cost, there are still various costs in running a ship. Those costs can be categorized into four parts: operating cost, periodic maintenance cost, voyage cost and cargo-handling cost. According to Stopford (2009), operating cost account for 14% of the total cost running a ship and it includes crew cost, store and maintenance cost in everyday's ship operation. Regular maintenance cost refers to the major maintenance such as dry-dock cost. Regular maintenance cost only takes 4% of the total cost. Voyage cost includes costs happened during a voyage, such as bunker and port cost, and accounts for 40% of the total cost. Cargo-handling cost refers to the cost of loading and discharging cargo at ports. However, cargo-handling cost only takes a small portion in total cost, because of the development of advanced cargo-handling facilities. Capital cost accounts for 42% of the total cost which is also one of the most important considerations for ship owners.

Revenue is the benefit that market participants can get from getting involved in shipping market activities. However, revenue comes with risk. The risk distribution between a ship owner and charterer is different under different charter formats (i.e. voyage charter, time charter or bareboat charter). Several strategies are usually applied to maximize revenue, such as optimizing the operating speed, maximizing loaded days at sea and optimize deadweight utilization.

At the company level, the cost and revenue information can be accessed through shipping accounts. Specifically, by reading the income statement, balance sheet and cash flow statement, investors can get a basic assessment of a shipping company.

In the research field of company level maritime economics, the popular topics include sources of finance, shipping investment and risk management (Alexandridis et al. 2018). Economic modeling is the most commonly applied method.

1.4 Research Questions of Thesis

The overall objective of this thesis is to develop a deeper understanding of shipping market economics. The objective is achieved through addressing below three research questions:

Q1. How do the scholar community, topics and research methods in the shipping market economics evolve in the past decades.

The first question will be tested through a bibliometrics analysis of papers focusing on shipping market economics. Moreover, the findings of first question provide directions for further research.

Q2. How important is the effect of seller and buyer's domicile on second-hand ship price.

The second question will be investigated with the help of a two-step regression. The first step captures the vessel age and market condition while the second step incorporates the domicile effect and ship specific factors.

Q3. How and why the seasonality in shipping freight rate market change, particularly considering the China effect.

The third question will be examined through a stochastic seasonality test. The observation period is separated into two sections, with a cutting point specifying when the China effect changes the seasonality pattern.

1.5 Thesis Structure

This thesis consists three studies. As shown in Figure 1-5, Chapter 2 provides a literature review on shipping market economics. Based on the future research directions of Chapter 2, two studies, second-hand ship price and freight rate seasonality in dry bulk market are selected to further investigate in chapter 4 and chapter 5.

Research background and literature review of the two studies are shown in Chapter 3. Their research methodologies and results are introduced separately in Chapter 4 and 5. Chapter 6 summarizes the findings and gives future research agenda.

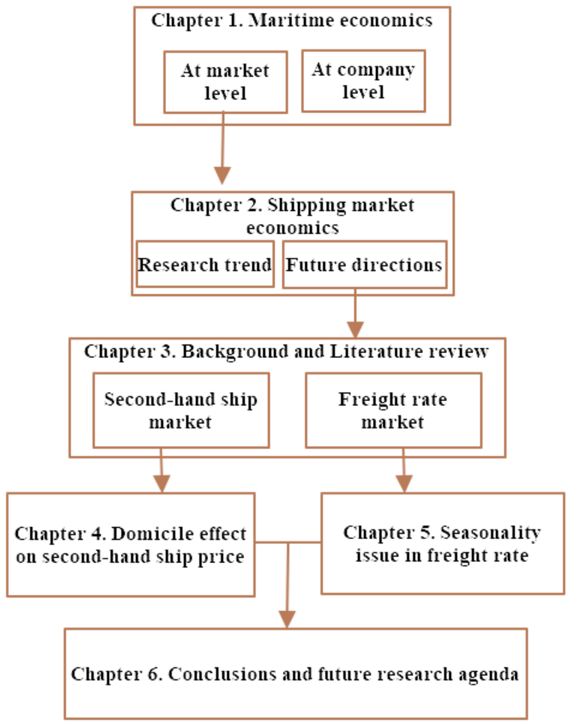


Figure 1-5. Flow chart of thesis structure

Chapter 2. Research Trend in Shipping Market Economics

2.1 Introduction

Following the introduction in Chapter 1, maritime economics can be introduced in two perspectives: (1) shipping market economics from the macro-perspective and (2) shipping company economics from the micro-perspective. This thesis focuses on the shipping market economics. Shipping market economics involves the study of organization of four shipping markets as well as the market mechanism at the market level. Specifically it focuses on supply, demand and freight rate theory and how it works within the four shipping markets. Research interests in shipping market economics are to quantify those market mechanisms through the applications of economic tools, such as econometrics and economic modelling which are applied to other similar capital markets.

The academic scope for maritime market economics is not clearly defined. Based on the Figure 1-2 in chapter 1, the research topics related to maritime market economics include "Shipping market, industry, freight rate, and economic impact" and "Shipbuilding, demolition, new orders and second-hand ships". Taking this scope as the start point, through careful searching and selection, 179 papers related to shipping market economics are collected from 38 scientific journals.

The objective of this chapter is to examine the evolution of research topics and methods in shipping market economics through the application of bibliometrics analysis. At the same time, it utilizes the node centrality analysis in weighted networks (Opsahl et al. 2010) to investigate the author collaboration. Based on the results, this study will further provide evidences on the relationship between author collaboration and citation. The results will shed light on the future development of research topics and methods in shipping market economics.

2.2 Methodology and Data

2.2.1 Data and overview

The database of this study is sourced from Scopus[1]. First this research selects research papers published in a pool of academic journals, to the best of our knowledge, relating to shipping market economics. Then this research further expands the database by, scanning the references of selected papers, checking studies who cite the selected papers, scanning relevant documents recommended by Scopus. After collecting a big portion of our database, this research makes supplement by examining other papers published by some productive researchers and high frequency journals in our database. The selection criteria includes keywords, abstract and methodology part of the papers. After careful selection, 179 papers are collected from 38 scientific journals, ranging from 1973 to the end of 2018. The names of journals are listed in Table 2-1 together with their paper counts and weights. We can observe that 67% papers are in the scope of maritime and transportation and 12% papers are within economics Journals. The annual academic paper production is illustrated in Figure 2-1.

Table 2-1. List of scientific Journals

	Journal Title	Count	SCI/SSCI/SCIE/ESCI	Proportion
1	Maritime Policy and Management	52	SSCI	0.29
2	Transportation Research Part E: Logistics And Transportation Review	32	SCIE/SSCI	0.17
3	Maritime Economics and Logistics	26	SSCI	0.15
4	Applied Economics	9	SSCI	0.05
5	Journal of Transport Economics and Policy	9	SSCI	0.05
6	Transportation Research Part A: Policy and Practice	7	SCIE/SSCI	0.04
7	International Journal of Shipping and Transport Logistics	3	SSCI	0.02
8	International Journal of Transport Economics	3	SSCI	0.02
9	Journal of Futures Markets	3	SSCI	0.02
10	Applied Economics Letters	2	SSCI	0.01
11	Energy Economics	2	SSCI	0.01
12	International Journal of Forecasting	2	SSCI	0.01
13	Marine Policy	2	SSCI	0.01
14	Review of Derivatives Research	2	SSCI	0.01
15	Transportation Research Part B: Methodological	2	SCIE/SSCI	0.01
16	American Economic Review	1	SSCI	0.01
17	Applied Financial Economics	1	-	0.01
18	Asian Journal of Shipping And Logistics	1	ESCI	0.01
19	Containerisation International	1	SSCI	0.01

[1] Scopus is a source-neutral abstract and citation database, curated by independent subject matter experts.
https://www.elsevier.com/__data/assets/pdf_file/0017/114533/Scopus_GlobalResearch_Factsheet2019_FINAL_WEB.pdf

Table 2-1(continued)

	Journal Title	Count	SCI/SSCI/SCIE/ESCI	Proportion
20	Economic Modelling	1	SSCI	0.01
21	European Financial Management	1	SSCI	0.01
22	International Journal of Information And Management Sciences	1	-	0.01
23	Journal of Banking And Finance	1	SSCI	0.01
24	Journal of Forecasting	1	SSCI	0.01
25	Journal of International Financial Markets, Institutions And Money	1	SSCI	0.01
26	Journal of Marine Science And Technology	1	SCIE	0.01
27	Journal of Traffic And Transportation Engineering	1	ESCI	0.01
28	Maritime Studies And Management	1	-	0.01
29	Panoeconomicus	1	SSCI	0.01
30	Quarterly Journal of Economics	1	SSCI	0.01
31	Review of Finance	1	SSCI	0.01
32	Review of Financial Economics	1	ESCI	0.01
33	Southern Economic Journal	1	SSCI	0.01
34	Transport Policy	1	SSCI	0.01
35	Transportation	1	SCIE/SSCI	0.01
36	Transportation Letters	1	SCIE/SSCI	0.01
37	Transportation Research Part D: Transport And Environment	1	SCIE/SSCI	0.01
38	Transportmetrica A: Transport Science	1	SCIE/SSCI	0.01
	Total	179		1.00

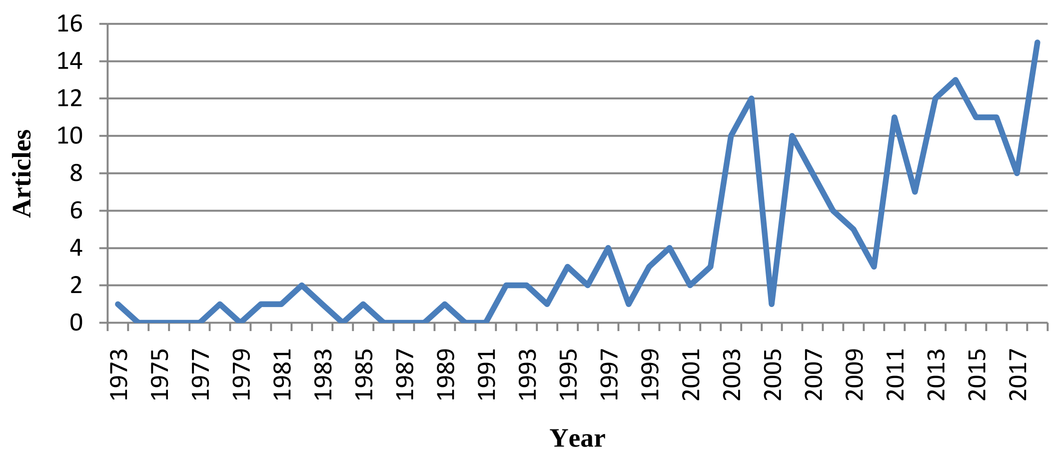


Figure 2-1. Annual academic paper production

Research collaboration is common as shown in the database with 149 out of 179 papers being co-authored. Altogether 189 academic researchers are involved within which 166 researchers appear in multi-authored papers. Figure 2-2 shows the visualization of co-authorship in social network analysis across the observation period. Authors with over 3 publications are tracked while independent authors are removed for simplicity. The size of each node represents the degree (the number of publications) of corresponding author. The edge linking two nodes represents co-authorship between authors and the thickness of the edge captures collaboration frequency between paired authors. For example, in the blue group, we can observe three core authors: Alizadeh AH, Kavussanos MG, and Nomikos NK. They have corporation with each other, while the number of co-authored papers between Nomikos NK and Alizadeh AH tends to be higher. In the purple group, the core author is Adland R. Though except Alizadeh AH, Adland R has no co-authorship with the other two core authors in blue group, these two groups could be linked through Alizadeh AH. Different colours denote groups clustered via random walks. We can observe four big groups with one or more core authors account for most of the research collaboration.

The co-authorship network can be treated as a Collaborate Network as defined in Vallejos et al. (2008). Through the collaboration among authors, the whole discipline can be stimulated by the Social Capital generated, such as social trust, fast information dissemination and high efficiency of problem resolution. The measure of Social Capital could be in three dimensions, which are: structural, relational and cognitive. In this study, the structural dimension of Social Capital is investigated. Specifically, the connections among authors are quantified through variables as Node Centrality.

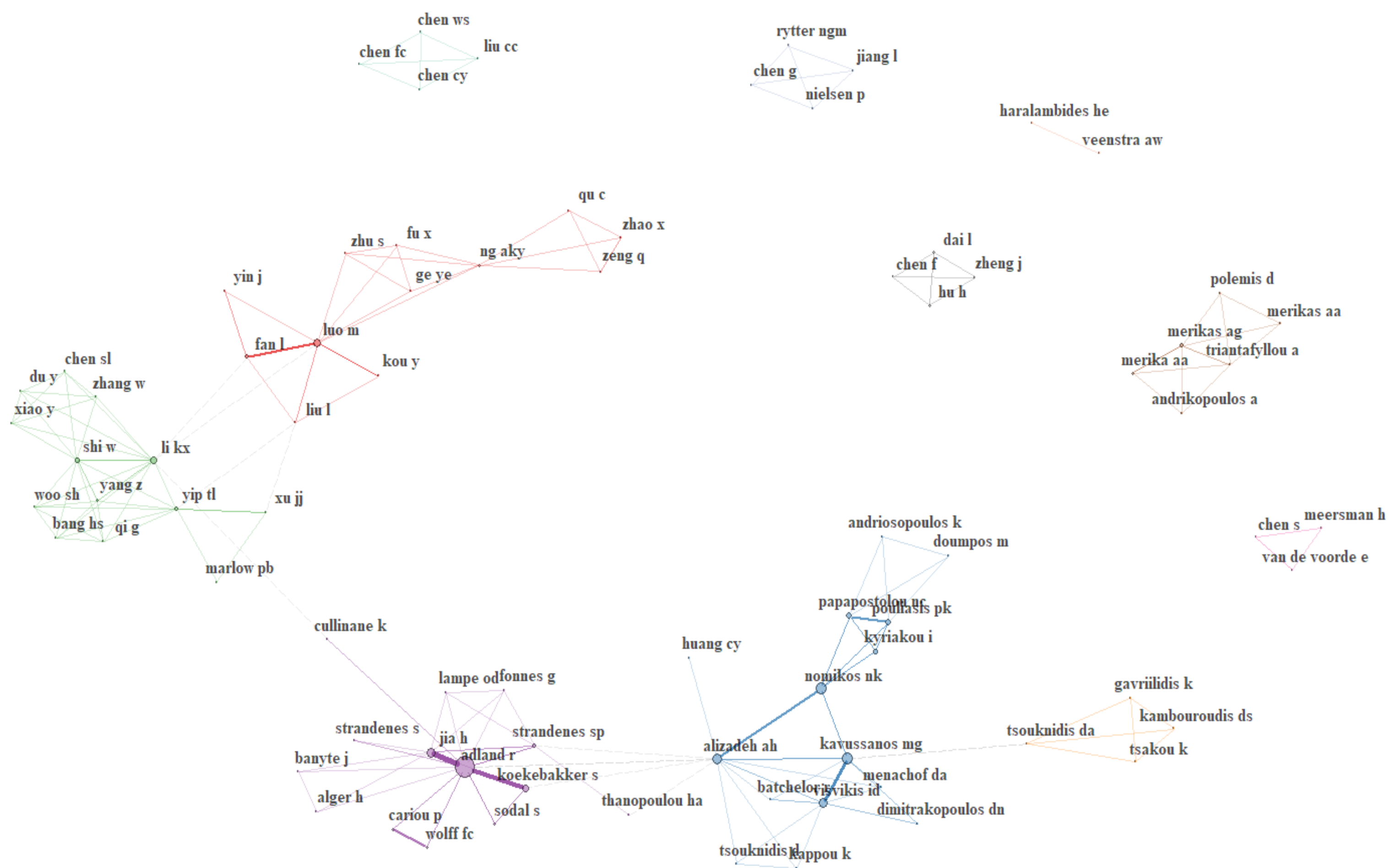


Figure 2-2. Co-authorship network in Shipping Market Economics (1973-2018)

2.2.2 Methodology

In order to quantitatively investigate the collaboration relationship among authors, this research adopts the node centrality analysis method in weighted networks (Opsahl et al. 2010). Node centrality aims to measure the relative importance of a node in the social network. Three factors are utilized to describe the node centrality, those are degree, closeness and betweenness originally constructed by Freeman (1978). Furthermore, these three factors are generalized for weighted networks which include the counts of edges and the weight of each edge. Then, Opsahl et al. (2010) introduced a turning parameter to incorporate both the count and the weight of edges into three measures.

Considering our social network in Figure 2-1, the degree defined by Freeman (1978) is formulated as:

$$k_i = C_D(i) = \sum_j^N x_{ij} \tag{2-1}$$

where index i denotes i-th author, and index j denotes the other j-th authors in the overall social network with N authors in total. The collaboration between i-th and j-th authors is denoted by dummy variable x_{ij} which is 1 if there is co-authorship and 0 if not. So k_i measures the number of authors who have co-authorship with i-th author.

In a weighted social network, the binary variable x_{ij} will be replaced by the weight of the tie. The degree formulation (2-1) becomes:

$$s_i = C_D^w(i) = \sum_j^N w_{ij} \tag{2-2}$$

where w_{ij} represents the co-authorship frequency between the i-th and j-th author. Therefore s_i measures the number of co-authored papers by i-th author.

Both indicators k_i and s_i reflect the node centrality of author i in social network from different perspectives. In an attempt to combine above two indicators, Opsahl et al. (2010) proposed a turning parameter α to define the relative importance of s_i over k_i. The degree measure finally takes the following formulation:

$$C_D^{w\alpha}(i) = k_i \times \left(\frac{s_i}{k_i}\right)^{\alpha} = k_i^{(1-\alpha)} \times s_i^{\alpha} \tag{2-3}$$

where α is a positive real number. When the value of α is between 0 and 1, with s_i being fixed, as k_i becomes larger, the value of degree C becomes larger. In this case, when an author builds more collaboration relationship with other authors, this author becomes more influential. When α equals to 0 or 1, the degree C will equal to one of the special conditions, i.e. k_i and s_i. If α is larger than 1 with s_i being fixed, as k_i increases, degree value C will decrease, which means that if an author's total number of co-authored papers is fixed, it is better to distribute the co-authored papers over fewer co-authors. However, regardless of the value of α, it is always a good idea to publish more co-authored papers (bigger s_i) to get more influence in social network (higher value of degree C).

The degree variable assesses the relative importance of one researcher in the network through the collaboration relationship between one author and his adjacent authors. However, if two authors have no collaboration experience but they both have worked with a third co-author, the degree factor is not able to depict this type of relationship. As a supplement, closeness and betweenness are utilized to indicate this type of relationship.

The measurement of closeness and betweenness rely on identification of the shortest paths between nodes. Similar with degree factor, the calculation of shortest paths also goes through the process that from simple binary network to weighted network with turning parameter. The final function determining the shortest path between i and j is formulated as:

$$d^{w\alpha}(i, j) = \min\left(\frac{1}{(w_{ih})^{\alpha}} + \ldots + \frac{1}{(w_{hj})^{\alpha}}\right) \tag{2-4}$$

The weight (collaboration frequency) between author i and intermediary authors h is defined as w_{ih}. The intermediary authors h include multiple authors and finally link to author j. As the weight grows, the tie between two authors becomes tight. Thus the converse operation is applied to fit the minimal function. The turning parameter α measures the trade-off between number and weight of ties. In the condition of $0 < \alpha < 1$, a shorter path (a path with less intermediary authors) composed of small weight of ties is preferable to a longer path with large weight of ties. On the contrary, when $\alpha > 1$, the weight of ties becomes more important than the number of ties. Therefore, longer paths with more intermediary researchers are favoured.

After applying the shortest paths algorithm, the closeness factor of i-th author can be determined according to:

$$C_C^{w\alpha}(i) = \left[\sum_j^N d^{w\alpha}(i, j) \right]^{-1} \quad (2\text{-}5)$$

where the closeness value is the inverse of sum of all shortest paths from i-th author to the other authors in the social network.

Since the shortest paths of arbitrary pairs of authors are available, this research can further define the betweenness factor of author i as:

$$C_B^{w\alpha}(i) = \frac{g_{jk}^{w\alpha}(i)}{g_{jk}^{w\alpha}} \quad (2\text{-}6)$$

where $g_{jk}^{w\alpha}$ is the number of shortest paths between arbitrary pair of nodes j and k, and $g_{jk}^{w\alpha}(i)$ is the number of those shortest paths passing through i-th author.

2.3 Author Collaboration in Shipping Market Economics

Based on three node centrality measures in weighted networks, this research calculates the degree, closeness and betweenness values for each author in the social network. This research manually sets turning parameter α equals to 0.0, 0.5, 1.0 and 1.5 in turn and compare the difference. Table 2-2 lists the ten most productive authors in shipping market economics. For direct comparison, same author sequence is applied in the following illustration of three centrality measures.

Table 2-2. Top-ten productive authors in shipping market economics

Author	Paper publication	Author	Paper publication
Adland R	29	Jia H	11
Kavussanos MG	22	Koekebakker S	10
Alizadeh AH	19	Luo M	10
Nomikos NK	16	Goulielmos AM	7
Visvikis ID	11	Fan L	6

In the next part, values of three centrality measures are calculated for all authors in the network and top-ten productive authors is listed in Table 2-3, 2-4 and 2-5.

Specifically, in Table 2-3, though some researchers have relatively less publication, they still have a high score of centrality degree due to their broad collaboration relationship, such as Luo M. When the alpha equals 1.5, which means more focus is put on the weight of ties (publication quantity), the score of Luo M decreases.

In Table 2-4, the score of closeness measures the linkage from one author to the other authors in the network. Basically, we can observe that authors with more publications are more closely linked to the network. The low score of Goulielmos AM is because most of his publications in shipping market economics are in an isolated research circle.

Table 2-5 provides the betweenness score which measures how often one researcher is located in the shortest paths joining two researchers. If the co-authors of one researcher are more likely to work independently with other researchers, the researcher's betweenness score tends to be high.

Table 2-3. Top-ten authors degree centrality

Author	$C_D^{w\alpha}$ in Equation (2-3), Alpha: turning parameter			
	Alpha=0.0	Alpha=0.5	Alpha=1.0	Alpha=1.5
Adland R	16	25.9	42	68.0
Kavussanos MG	10	16.1	26	41.9
Alizadeh AH	15	19.4	25	32.3
Nomikos NK	8	13.0	21	34.0
Visvikis ID	12	15.9	21	27.8
Jia H	9	13.1	19	27.6
Koekebakker S	4	7.7	15	29.0
Luo M	11	14.1	18	23.0
Goulielmos AM	6	6.5	7	7.6
Fan L	5	7.1	10	14.1

Table 2-4. Top-ten authors closeness centrality

Author	$C_C^{w\alpha}$ in Equation (2-5), Alpha: turning parameter			
	Alpha=0.0	Alpha=0.5	Alpha=1.0	Alpha=1.5
Adland R	36.0	40.7	47.8	59.8
Kavussanos MG	30.8	38.1	44.0	48.0
Alizadeh AH	37.0	39.8	42.5	44.1
Nomikos NK	29.5	36.7	41.6	43.0
Visvikis ID	30.6	34.4	39.5	43.3
Jia H	27.5	34.1	41.6	51.7
Koekebakker S	28.3	34.8	41.8	50.1
Luo M	28.3	28.4	27.5	25.3
Goulielmos AM	6.0	5.6	4.9	3.9
Fan L	24.6	25.9	25.9	24.2

Table 2-5. Top-ten authors betweenness centrality

Author	$C_B^{w\alpha}$ in Equation (2-6), Alpha: turning parameter			
	Alpha=0.0	Alpha=0.5	Alpha=1.0	Alpha=1.5
Adland R	1745.8	1781.5	1786.8	1785.0
Kavussanos MG	326.3	402.0	789.5	789.0
Alizadeh AH	1629.2	1561.0	1551.0	1551.0
Nomikos NK	561.0	561.0	561.0	561.0
Visvikis ID	357.8	310.0	377.5	378.0
Jia H	14.5	4.0	4.0	4.0
Koekebakker S	27.0	14.5	14.3	15.0
Luo M	830.6	815.6	835.5	837.5
Goulielmos AM	14.0	14.0	14.0	14.0
Fan L	109.2	146.5	175.5	174.5

After getting those centrality scores, one interesting topic arises that how centrality score reflects author's influence in the social network. If one author gets a high centrality score, will he have more influence in social network? The measure of influence can be very flexible. One objective measure is the number of citations. Therefore, the question becomes that, if one author gets a high score in the centrality measure of the network, will the number of citations of that author also be high?

As the time and effort of one author are limited, the author cannot expand his/her research collaboration unlimitedly. Under the condition that one author's total research output (s_i in equation 2-2) is fixed, collaborating with more authors (higher k_i) but with fewer co-authored papers per person or concentrating on working with fewer co-authors (lower k_i) but more co-authored papers per person, which strategy can improve the citation efficiently.[2]

Following these two questions arising from centrality measure, here this research raises the hypothesis:

H1. Author's the number of citations is positively related to his/her centrality score in the social network.

H2. It is not always beneficial to collaborate with more co-authors, under the condition of total publication proxy is fixed.

The citation index of authors can take many formats, such as h-index and total citations per year. Since our research topic is about shipping market economics and many authors also publish papers in other subjects, this research only counts citations of papers in our database as the author's citation index and then investigate its relationship with centrality score. The top-ten citation index of authors is presented in Table 2-6. Compared with top-ten productive authors in Table 2-2, there is an inconsistency between publication quantity and citations.

Table 2-6. Ten most cited authors

Author	Citations	Author	Citations
Kavussanos MG	781	Koekebakker S	199
Visvikis ID	501	Cullinane K	157
Alizadeh AH	466	Veenstra AW	116
Adland R	408	Beenstock M	109
Nomikos NK	343	Tvedt J	104

This research starts with the simplest method, the linear regression, to investigate the relationship between the number of citations and the centrality score. This research regresses the citations on

[2] The assumption of fixed research output is based on the limited time and effort of authors. However, this assumption neglects the potential research output increase as a consequence of collaboration with more co-authors. Because the main purpose of this hypothesis is to investigate whether distributing the work with more or less co-authors could increase the author's citation. The assumption of fixed output facilitates the next step analysis.

three centrality index (degree, closeness and betweenness) one by one. The regression results are shown in Table 2-7.

Table 2-7. Regression results for citation on three centrality measures

Variable	Turning parameter	Coefficient value	P-value of coef	R-squared
Degree	0	21.3	0	0.37
	0.5	17.7	0	0.49
	1	12.7	0	0.56
	1.5	8.4	0	0.58
Closeness	0	3.0	0	0.13
	0.5	3.3	0	0.18
	1	3.9	0	0.26
	1.5	4.6	0	0.37
Betweenness	0	0.2	0	0.31
	0.5	0.2	0	0.32
	1	0.2	0	0.40
	1.5	0.2	0	0.40

We can observe that coefficient values are all positive and statistically significant, which confirms our hypothesis H1.

H1 (Not rejected) Authors' number of citations is positively related to their centrality score.

Because three centrality measures have different order of magnitudes, it is meaningless to compare coefficients across measures. Within one measure, we can observe that for Degree measure, as α exceeds value 1, the coefficients decrease. This indicates the following findings:

H2-1. Under the condition that one author's total number of collaborated works are fixed, i.e. s_i in equation (2-3) is fixed, and $\alpha > 1$, as the number of co-authors (k_i in equation (2-3)) becomes larger, the value of degree measure becomes smaller. Meanwhile, the coefficients also become smaller (compared to $0 < \alpha < 1$). As a result, the total citations become smaller. Therefore, it is a good practice for authors to work with fewer co-authors to raise his/her citations.

H2-2. However, under the condition that one author's total number of collaborated works are fixed and $0 < \alpha < 1$, as the number of co-authors becomes larger, the value of degree becomes larger. While the coefficient also becomes larger (compared to $\alpha > 1$). The citation of the author increases. Then it is a good practice for authors to work with more co-authors to raise his/her citation.

Based on findings H2-1 and H2-2, the hypothesis H2 can be also demonstrated.

H2. (Not rejected) It is not always beneficial to collaborate with more co-authors, under the condition of total research output is fixed. The decision depends on the value of α .

Then for Closeness measure, the coefficients are positively related to α . But the relationship between number of co-authors and closeness value is unpredictable. As for Betweenness measure, the relationship among α , number of co-authors and value of betweenness are even more complex. It is infeasible to elaborate the results based on closeness and betweenness value.

2.4 Evolution of research topics

In the Scopus database, this research has obtained two kinds of keywords, i.e. keywords specialised by authors and keywords indexed by Scopus. Both of the keywords cover various classifications of papers, such as disciplines, research methods and data analysis techniques. As a result, keywords analysis of those keywords is a general description of papers without a focus on specific categories. In Figure 2-3 and 2-4, this research illustrates the word cloud for both keywords by Scopus and authors. In each figure, 50 keywords with the highest frequency are illustrated. The font size corresponds to the keyword's frequency. We can see for both cases, "shipping" is the dominant keyword which depicts the discipline of the papers. For keywords by Scopus, "freight transport" and "transportation economics" which describe the classification of the paper, account for the second highest keywords frequency. While for keywords by authors, data analysis technique "cointegration" also takes a big portion. We can also spot some keywords with the same meaning but are counted separately, like "bulk shipping", "dry bulk" and "dry bulk shipping".

Figure 2-3. Word Cloud of keywords indexed by Scopus

Figure 2-4. Word Cloud of keywords specified by authors

However, for one-third of the papers, their keywords specialised by authors or keywords by Scopus are not available in the dataset. It is not comprehensive nor reliable if this research analyzes those keywords without making some supplements. Therefore, this research makes a list of research topics of our own. This research concludes the research topics for each paper by reading their titles and abstracts carefully. This research tries to make sure each topic can depict the research objective specifically and comprehensively, at the same time, without loss of consistency. Table 2-8 provides the list of summarized topics.

Table 2-8. Lists of research topics and their frequency

Research topics	Freq.	Research topics	Freq.	Research topics	Freq.
Freight Rate	27	Market Switching	2	International Maritime Exchange	1
Dry Bulk	17	Risk Management	2	Internet Disclosure	1
Tanker Market	15	Ship Age	2	Investment Incentives	1
Forecasting	14	Ship Price	2	Iron Ore	1
Spot Freight Rate	12	Shipping Derivatives	2	KG Funds	1
Volatility	10	Shipping Speed	2	Lead Lag Relationship	1
FFA	9	Systematic Risk	2	Leverage Effect	1
Freight Future Market	7	Voyage Charter Rate	2	Liquidity Risk	1
Inter Market Relationship	7	AIS Data	1	LPG	1
Volatility Spillovers	7	Asymmetrical Information	1	Market Concentration	1
Maritime Economics	5	Bank Loans	1	Market Cycles	1
New Building Price	5	Bulk Shipping Pools	1	Marlow Model	1
Second Hand Ship Price	5	Capacity Utilization	1	Model Evaluation	1
Time Charter Rate	5	Capital Structure	1	New Building Market	1
Trading Strategies	5	Cash Flow Sensitivities	1	Newbuilding Investment	1
Intra Market Relationship	4	Charter Market	1	Northern Sea Route	1
Maritime Investment	4	Charter Owner Effect	1	Oil Derivatives	1
Demolition Market	3	China	1	Physical Basis Risk	1
Dry Bulk Shipping Investment	3	Commodity Market	1	Port Privatization	1
Expectation Theory	3	Container Shipping Investment	1	Pricing System	1
Freight Options	3	Container Terminal	1	Risk Premium	1
Investment Timing	3	Container Transshipment	1	Ship Financing	1
Seasonality	3	Credit Spreads	1	Ship Investment	1
Ship Price Cycle	3	Crude Oil Price	1	Ship Size	1

Table 2-8 (continued)

Research topics	Freq.	Research topics	Freq.	Research topics	Freq.
Trading Volume	3	Default Risk	1	Shipping Bonds	1
Bunker Price	2	Delivery Lag	1	Shipping Stock	1
Contract Times	2	Double Hull	1	Spatial Efficiency	1
Energy Efficiency	2	Economic Performance	1	Structural Changes	1
Flag Choice	2	Ferry Boat	1	Tanker Fleet Capacity	1
Freight Futures	2	Financial Crisis	1	Tanker Investment	1
Freight Rate Cycle	2	Forward Charter Rate	1	Technical Changes	1
Freight Rates	2	Forward Freight Rate	1	Time To Build	1
Hedge Ratios	2	Forward Ship Value Agreements	1	Trip Charter Rate	1
Hedging	2	Freight Rate Formation	1	Unbiasedness Hypothesis	1
Investor Sentiment	2	Freight Rate Stationarity	1	Vessel Size	1
Liner Shipping	2	Fronthaul And Backhaul	1	VLCC Tanker	1
Market Efficiency	2	Individual Fixture	1		

Remark: FFA (Freight Forward Agreement), AIS (Automatic Identification System), KG fund (Kommanditgesellschaft fund), LPG (Liquefied Petroleum Gas), VLCC (Very Large Crude Carrier).

In order to illustrate the evolution of research topics, the whole research period is separated into four sub-periods with 2001, 2007 and 2013 as cut points.[3] The thematic maps (Cobo et al., 2011) are illustrated separately for four sub-periods in Figure 2-5. In the thematic map, X-axis denotes centrality which measures the relative importance of topics in the entire sub-period. Y-axis denotes density which measures the development of topics. Therefore, four quadrants represent different conditions of topics. Specifically, topics in the upper-right quadrant which have the highest importance and development are motor topics. In the lower-right quadrant, topics are important but have lower development. These topics compose the basic research filed in the sub-period. In the upper-left quadrant, topics are less important but have high development. Topics in this quadrant are more specialized and isolated like a niche market. Topics in the lower-left quadrant are emerging or disappearing themes.

[3] The criteria to select cut points is to make sure each sub-period contains enough papers to draw the thematic map. In this study, each sub-period includes at least 40 papers.

Each circle in the thematic maps represents a cluster of research topics. The clustering algorithm is the simple centers algorithm. The name of the circle denotes the central topic in this cluster. The circle size represents the number of research papers in corresponding themes. However, the thematic map is rather intuitive. For each cluster in the thematic map, only the central topic is visible and the rest of topics in the cluster will not be shown. In addition, though other topics in one cluster are closely related to the central topic through similarity analysis, the central topic in one cluster cannot be treated as the categorization factor. This means the central topics might not depict the overall cluster comprehensively. Though there are some limitations with the thematic map, it is still a scientific and representative method to show the complex research topics in an understandable and straightforward way.

Then through linking the "thematic nexus" of topics in four sub-periods, we can further highlight the merging and splitting of topics along the timeline, and illustrate the evolution of thematic clusters in shipping market economics.[4] The results are presented in Figure 2-6. For each thematic cluster in Figure 2-6, Table 2-9 provides its including topics. A thematic cluster is defined as a group of evolved research topics across different sub-periods. Therefore, same research topics may appear in different thematic clusters in different sub-periods. Some thematic clusters may come from nowhere (Cobo et al., 2011).

[4] We do not include the methodology part of drawing the Thematic map and Thematic evolution map, as it is not the focus of this study. For a systematic introduction, please refer to Cobo et al. (2011).

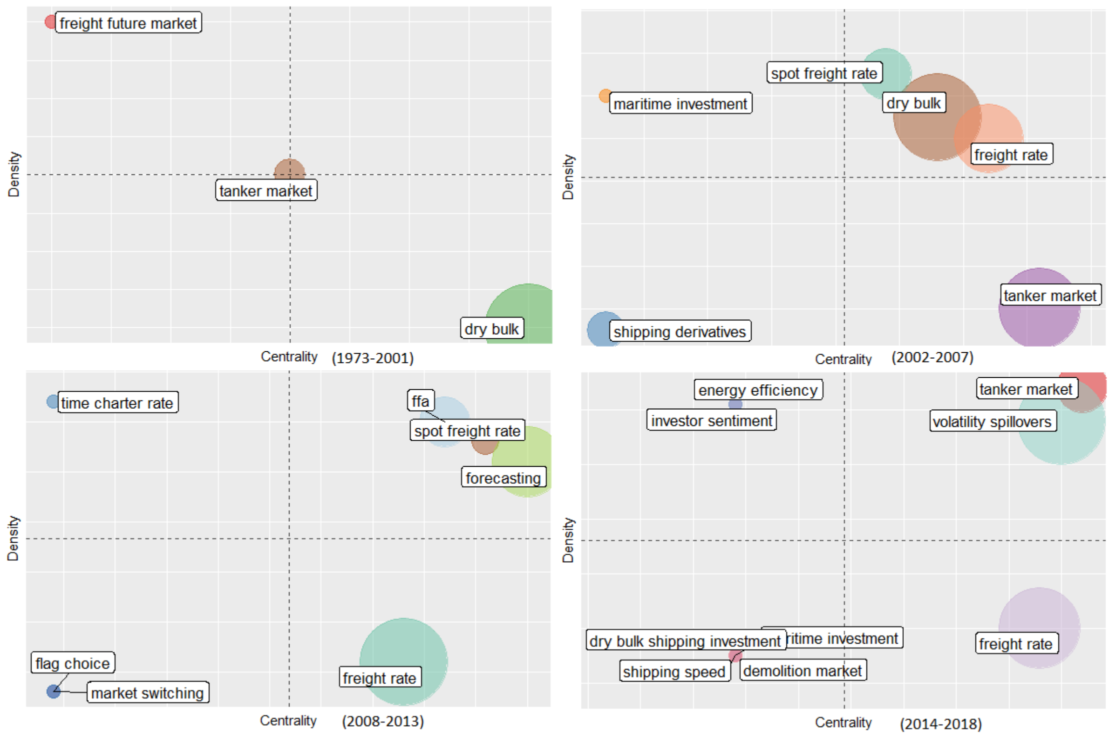


Figure 2-5. Thematic maps for four sub-periods

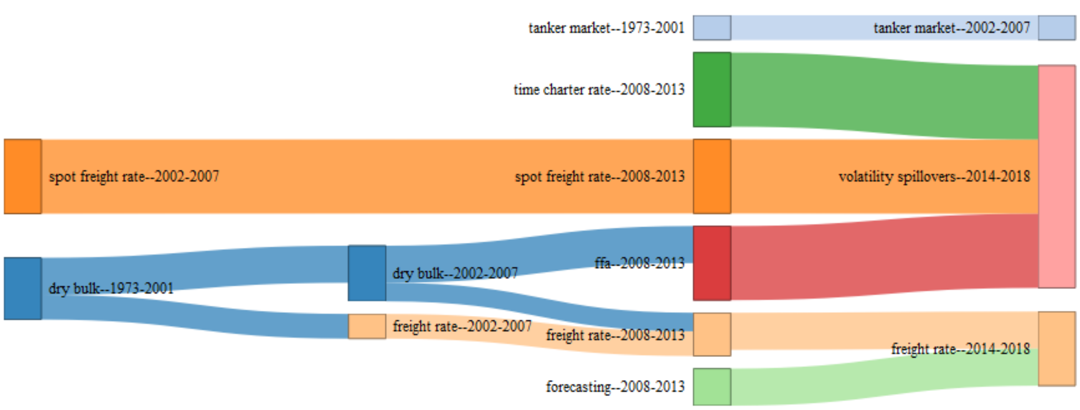


Figure 2-6. Evolution of research topics

Table 2-9. Evolution of research topics

Sub-period	Cluster label	Following topics and their frequency in parentheses
1973-2001	Dry bulk	Dry bulk (7) Freight rate (4) Inter-market relationship (3) Volatility (2)
	Tanker market	Tanker market (5) Maritime economics (5) Ship age (2)
2002-2007	Spot freight rate	Spot freight rate (6)
	Dry bulk	Dry bulk (7) Second-hand ship price (4) FFA (3) Volatility (3)
	Freight rate	Freight rate (5) Expectation theory (3) Bunker price (2)
	Tanker market	Investment timing (2) Tanker market (7) Trading strategies (5)
2008-2013	Time charter rate	Time charter rate (2)
	Spot freight rate	Spot freight rate (3)
	FFA	FFA (4) Volatility spillovers (2)
	Freight rate	Freight rate (10) Volatility (4) New-building price (4) Contract times (2)
	Forecasting	Forecasting (8) Ship price cycle (3)
2014-2018	Volatility spillovers	Volatility spillovers (5) Dry bulk (3) Spot freight rate (3) FFA (2) Time charter rate (2) Intra-market relationship (2)
	Freight rate	Freight rate (8) Inter-market relationship (2) Forecasting (2) New-building price (2)

Note: a number in brackets ( ) indicates the number of publications.

Through a combined analysis of Figure 2-5 and 2-6, we can see in shipping market economics, dry bulk market research composed the biggest and basic research field in the beginning. Then the dry bulk research got further developed and became the motor theme. Part of the dry bulk research split and developed into the freight rate research. After 2008, due to the influence of the financial crisis, dry bulk research became less. One part of it turned into freight rate research and the other flowed into FFA research. After 2014, dry bulk research returned, but acted as an emerging topic combined with investment conception.

As for researches in tanker market, it was a central topic before 2001. After 2002, part of it turned into dry bulk market research and a new tanker market research field emerged and formed the basic research theme. However, after 2008, the tanker market research disappeared for a certain time. Then after 2014, tanker market research had redeveloped into a motor topic in shipping market economics. This research attributes this change to the financial crisis in 2008 which overturned the previous research insights and drove the tanker market research into a new era.

For freight future market, it had already been investigated as a specialized topic in the very beginning. After 2002, traditional freight future market disappeared while a new term "shipping derivatives" came into existence. After 2008, the freight future market research developed into a motor topic including FFA and forecasting. But after 2014, freight future research was likely to be at a standstill.

Freight rate research evolution is stable and longlasting. It first appeared with the development of dry bulk market research after 2002. At the same time, spot freight rate formed a unique research topic isolated from freight rate. Both of the two topics were motor topics. After 2008, part of the dry bulk research merged with freight rate and freight rate research became the basic research field. After 2014, freight rate research had gained some development from the forecasting section and still acted as the basic topic in shipping market economics.

Except for above topics which have clear evolution processes, there are also some unique topics appearing at different sub-periods. "Maritime investment" is first investigated after 2002 as a specialized topic. The concept and method of "maritime investment" are likely to be borrowed from other capital markets. Therefore this topic is well developed but not many researchers have paid attention to this topic which makes this topic a specialized area. After 2008, under the influence of the financial crisis, "maritime investment" disappeared. Later on, "maritime investment" re-appeared after 2014, but as an emerging research topic. "Flag choice" and "market switching" are new research topics emerging after 2008. However, these two topics have not existed for long. After 2014, other new topics "demolition market", "shipping speed" and "dry bulk shipping investment" emerged. In the specialized section, two topics "investor sentiment" and "energy efficiency" were included. At the same time, a new topic "volatility spillovers", which is evolved from "time charter rate", "spot freight rate" and "FFA", acted as the motor topic in the 2014-2018 sub-period.

After 2014, the "investment" concept became popular. Researches related to this topic can provide more practical guidance in the decision making process. Also due to the development of big data in the shipping market, such as AIS, some new research topics like "shipping speed" and "energy efficiency" are able to be investigated.

2.5 Evolution of research methods

The "research methods" are extracted and summarized from the Methodology part of each paper. Most of the methods are data analysis techniques from econometrics. Our database also includes papers dealing with modeling, optimization and review. In those cases, the methods are defined as general descriptions of their methodology without further specification. The reason to give general description is for consistency of methods, otherwise, the research methods for those papers would be scattered and could not form a valid cluster.

The top ten research methods are summarized in Table 2-10. The modeling technique takes the biggest portion. The main purpose of modeling is to quantitatively simulate the market mechanism which is hidden behind empirical practice. Though there are many different types of models, numerical study methods and model calibration techniques, the basic process of modeling technique is similar among papers, e.g. model setup, raise hypothesis and model validation and calibration. For other research methods, time series analysis methods have the highest frequency. For most papers, they can have multiple research methods because those research methods are not exclusive to each other, such as the VECM is often utilized along with the cointegration test.

Table 2-10. Frequent research methods

Research methods	No. papers	Research methods	No. papers
Modeling	32	VAR	16
GARCH	30	Cross validation	13
VECM	30	Impulse response analysis	9
Linear regression	20	Qualitative analysis	9
Cointegration test	17	Real option	9

In Figure 2-7, this research draws the Sankey diagram of three elements, i.e. author, topics and research methods. The Sankey diagram is originally applied in energy industry to reflect the heat flows among complex elements. Then it is extended to economy and resources aspects (Schmidt, 2008). The width of each line represents the proportion of information flows. In our case, the Sankey diagram shows how the top ten authors are dedicated to frequent research topics and then how the research topics are investigated through various research methods.

In the left chart of Figure 2-7, the information flow between authors and topics is illustrated. We can see that Kavussanos MG has the widest research interests. Freight rate topic attracts the most attention from researchers. In the right chart of Figure 2-7, we can observe VECM is most widely applied in various topics while GARCH has the biggest proportion in applied methods. Overall freight rate topic has the highest information flow which also demonstrates its basic topic status in shipping market economics.

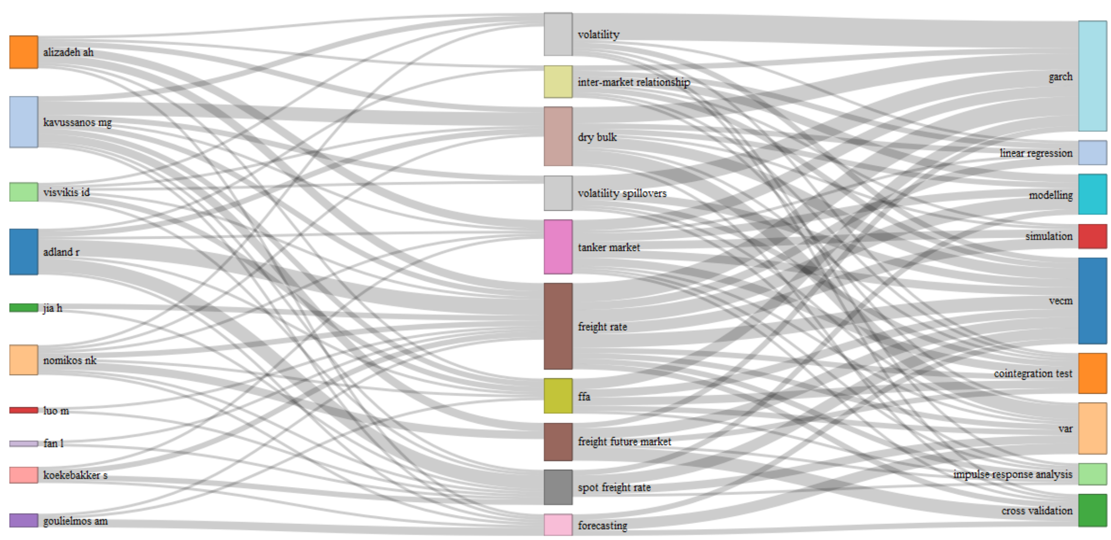


Figure 2-7. Sankey diagram of author, research topics and research methods

Finally, Figure 2-8 illustrates the evolution of research methods through four sub-periods, i.e. 1973-2001, 2002-2007, 2008-2013 and 2014-2018. The evolution process is calculated by comparing thematic maps of research methods in four sub-periods. Please refer to Table 2-11 for specifications of each cluster in Figure 2-8.

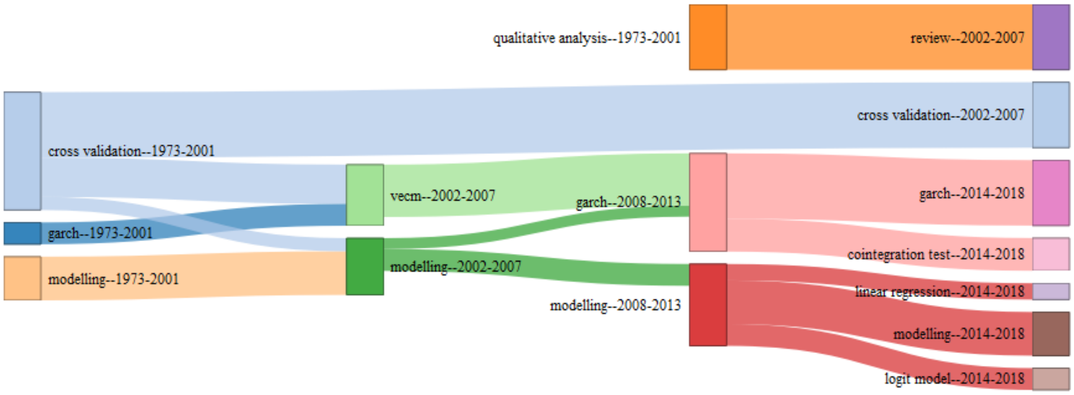


Figure 2-8. Evolution of research methods

Table 2-11. Evolution of research methods

Sub-period	Period characteristics	Cluster label	Following topics and their frequency in parentheses
1973-2001	Exploring	Qualitative analysis	Qualitative analysis (6) Quantitative analysis (2) Review (2)
		Cross validation	VAR (3) Within sample test (2) VECM (4) Cointegration test (3) Cross validation (5)
		GARCH	Seasonal unit root test (2) Optimization (3) GARCH (5)
		Modeling	Modeling (7) Simulation (3) Linear regression (7)
2002-2007	Booming	Review	Review (4) Qualitative analysis (3)
		Cross validation	Cross validation (5)
		VECM	VECM (14) VAR (5) Impulse response analysis (2) GARCH (9) Within sample test (2)
		Modeling	Real option (3) Cointegration test (5) Modeling (7) Partial equilibrium model (2) Simulation (3) Stationary bootstrap (2)

Table 2-11 (continued)

Sub-period	Period characteristics	Cluster label	Following topics and their frequency in parentheses
2008-2013	Contracting and absorbing	GARCH	VAR (4) Impulse response analysis (2) GARCH (7) ARIMA (2) VECM (5) Cointegration test (2)
		Modeling	Logit model (2) Optimization (2) Multiple hypothesis test (3) Superior predictive ability (2) Real option (3) Linear regression (4) Modeling (6) simultaneous equations model (4)
2014-2018	Expanding	GARCH	GARCH (9) Impulse response analysis (5) VAR (4) VECM (7)
		Cointegration test	ARMAX (2) Cointegration test (7)
		Linear regression	Linear regression (8) Fixed effect (5) Statistics (2) Cross validation (2)
		Modeling	Real option (3) Modeling (12) Unit root test (3)
		Logit model	Logit model (4) Simulation (2) Within sample test (2)

Note: a number in brackets ( ) indicates the number of publications.

Remark: VAR (Vector Autoregressive Model), VECM (Vector Error Correction Model), GARCH (Generalized Autoregressive Conditional Heteroskedasticity Model), ARIMA (Autoregressive Integrated Moving Average Model).

Within 1973-2001, the research methods are in the stage of exploring. Various methods are applied. The most applied technique is the cross validation (also known as out-of-sample test) which is often utilized to test the model's forecasting ability. Qualitative analysis also takes a big portion. Papers utilizing qualitative analysis are mostly about introducing a new concept (Haralambides, 1996; Zenon, 1973), policy (Lee, 1999) or discipline (Metaxas, 1983, 1980).

Modeling at that time is focused on incorporating various influencing factors to the shipping market (Hawdon, 1978; Charemza and Gronicki, 1981; Miyashita, 1982; Beenstock, 1985; and Beenstock and Vergottis, 1989), therefore modeling is often together with linear regression. GARCH model has just been introduced into the shipping market from the financial market. Its application focuses on investigating risk and volatility properties in dry bulk (Kavussanos, 1996, 1997) and tanker market (Glen and Martin, 1998) indexes. Then GARCH is further applied to BIFFEX (Baltic International Freight Futures Exchange) market (Kavussanos and Nomikos, 2000a, 2000b).

Within 2002-2007, with the development of econometrics in time series data, such as GARCH, the research methods stimulate the research outputs in shipping market economics. We can observe that researches previously applying qualitative analysis turned into review methods. The review objectives include risk premium in bulk freight rate (Adland and Cullinane, 2005), bulk and tanker modeling (Glen, 2006) and freight derivatives (Kavussanos and Visvikis, 2006). A "new" technique, VECM, which was introduced together with GARCH (Kavussanos and Nomikos, 2000), was applied by part of researches from cross validation and the whole section of GARCH. Actually, during this period, the GARCH model was still actively applied. But it was categorized into the VECM cluster. VECM aims at modeling time series data with its deviation from its long-run equilibrium in the previous period. In shipping market, it was often extended to model relationships between cointegrated variables, such as spot and time charter rate in dry bulk market (Kavussanos and Alizadeh, 2002) and tanker market (Kavussanos, 2003), freight derivatives and spot freight rate (Kavussanos and Nomikos, 2003; Kavussanos and Visvikis, 2004; Kavussanos et al., 2004 and Batchlor et al., 2007) and earnings and ship price in tanker market (Alizadeh and Nomikos, 2006, 2007). GARCH model in this period was developed to investigate the factors influencing volatility of shipping indexes, such as risks in period charter in dry bulk (Kavussanos and Alizadeh, 2002) and tanker market (Kavussanos, 2003), volatility in freight futures market (Kavussanos et al., 2004; and Kavussanos and Visvikis, 2004). Modeling and cross validation still prevailed in this period. The modeling objectives in this period were focused on specific factors in the shipping market, like forward freight dynamic (Koekebakker and Adland, 2004), freight rate option (Koekebakker et al., 2006) and spot freight (Adland and Strandenes, 2007).

During 2008-2013, the variety of research methods is contracting. At the same time, some methods are absorbing new components and keep active in shipping market economics. Only two research methods were left active in shipping market economics. GARCH model had again received much attention from researchers. Various transformations of GARCH model were adopted, such as EGARCH (Jing et al., 2008; and Alizadeh and Nomikos, 2011) and AR-GARCH (Xu et al., 2011). Except for traditional index volatility analysis, a new application of GARCH model was to investigate volatility spillover effect (Kavussanos et al., 2010; and Chen et al., 2010). Modeling in this period was focused on formulating new conception's influence on the shipping market, such as default risk (Adland and Jia, 2008), technical changes (Chen et al., 2010) and market switching (Sødal et al., 2008, 2009).

Within 2014-2018, the cluster of research methods became expanding. We can see except for GARCH and modeling, other techniques like cointegration test, linear regression and logit model had also formed their unique cluster. In the application of GARCH method, new interesting factors which are outside of the shipping market are adopted, for example, commodity futures (Kavussanos et al., 2014), stock price (Alizadeh and Muradoglu, 2014) and oil price (Gavriilidis et al., 2018). Volatility spillover became a popular application of GARCH (Kavussanos et al., 2014; Li et al., 2014; Dai et al., 2015; and Tsouknidis, 2016). Modeling technique in this period focused on decision-making of ship investment (Kalouptsidi, 2014; Greenwood and Hanson, 2015; Kyriakou et al., 2018; and Luo and Kou, 2018). The broader application of the Logit model also reflected the development of individual decision factors in shipping market economics. The regain of popularity by linear regression reveals that the research focus in shipping market economics is moving from methodology to topic in recent years. New interesting topics became favorable like investor sentiment (Papapostolou et al., 2016), fuel efficiency (Adland et al., 2017), ship speed (Adland et al., 2017; and Adland and Jia, 2018) and vessel capacity utilization (Adland et al., 2018).

Here we need to emphasize that, due to the limitation of thematic maps we mentioned in 2.4, the emergence of new research methods does not necessarily mean those methods were not utilized in previous researches. In most of the cases, those methods are already applied in the research field but may not be visible as they were clustered into other topics. Table 2-11 gives a list of words following each cluster. Therefore, we can tell in recent four years, those methods have gained much development and formed their unique methodological system.

2.6 Chapter conclusions and future research directions

2.6.1 Conclusions

In this chapter, through the bibliometrics analysis of author collaboration, evolution of research topics and methods of 179 papers from 38 scientific journals, this study tries to provide some evidences on the development of shipping market economics.

First, in the social network, research collaboration is shown to be strongly correlated with the authors' productivity (Lee and Bozeman, 2005). To evaluate an author's influence in the academic field, both productivity and citations are important factors. This study provides a different perspective on the relationship between research collaboration and citation. Two hypotheses are raised and accepted, which reveals the below findings.

Through the application of node centrality analysis, authors' influence in the social network is quantified in three measures i.e. Degree, Closeness and Betweenness. All three measures are positively related to the citation. It is a good practice for researchers to improve their citations by participating more actively in research collaboration network. However, it is not always beneficial to collaborate with more co-authors. The decision to work with more or fewer co-authors depends on the selection of the turning parameter α in weighted networks. Specifically, under the condition of the total productivity of one author is fixed, building more connections with other authors is beneficial when the focus is put on degree factor ($0 < \alpha < 1$); but when the evaluation system puts more focus on strength factor ($\alpha > 1$), it is preferable to build fewer connections. In the current shipping market economics, this research believes the emphasis is put on degree factor. Therefore building a wide collaboration work is always a good practice. While in certain disciplines which involves big-scale teamwork and a large number of authorship, it is better to put the evaluation focus on strength factor.

Second, the evolution of research topics in shipping market economics seems like going from narrow to wide and then back to narrow. The observation period is divided into four sub-periods based on paper quantity. For the time period 1973-2001, "dry bulk" and "tanker market" are the research focus. Then in 2002-2007, with the rapid development of shipping industry, more specific research topics like "freight rate" and "spot freight rate" are emerging. The financial crisis in 2008 brings some changes to the development of research topics in 2008-2013. One obvious phenomenon is that two big research areas "dry bulk" and "tanker market" disappear. As a substitution, some risk hedging topics like "FFA" and "Forecasting" topics become popular. The research topics are also focused on detailed and specialized areas, such as "freight rate", "spot freight rate" and "time charter rate". In the following 2014-2018, most of the research topics are clustered into three thematic groups, i.e. "volatility spillover", "freight rate" and "tanker market". Through Table 2-9 we can see, in 2014-2018, the research topic variety does not decrease, but those specific topics are organized into a more structured thematic group.

Though the numbers of thematic clusters are both low in 1973-2001 and 2014-2018, the definition of "narrow" is different between two sub-periods. In 1973-2001, researches in shipping market economics are at the stage of exploring. The research topics are of a low variety and dispersed. Then shipping industry goes through the peak and trough in 2002-2014. In the period of 2014-2018, we can observe a significant increase in the variety of research topics. But unlike the previous sub-periods in which research topics are more focused on various specialized areas, research topics in last four years are more closely linked to each other. As a result, the shipping market economics is becoming systematic and inclusive.

As for the specification of the research topics, the freight rate research has always been a general and basic theme in shipping market economics. Although freight rate has an important position in research field, this topic has not gained much development in past decades. Dry bulk market research is gradually disappearing and spread into specific and specialized research areas, such as FFA and volatility spillovers. Research on tanker market has gained much increase in both its importance and development in shipping market economics. We can observe tanker market starts as a central topic in 1973-2001 (moderate importance and development); then as a basic topic in 2002-2007 (high importance but low development); while 2008-2013 is a blank period for tanker market research; finally in 2014-2018, tanker market research becomes the motor topic in shipping market economics (high importance and high development). Future works in shipping market economics are expected to put focus on tanker market and volatility spillovers as well as freight rate.

Third, in shipping market economics, the most often applied research methods are econometrics and modeling. The modeling technique is always a straightforward way to simulate the market mechanism based on the authors' hypothesis. Therefore we can observe the evolution of modeling technique has never stopped in four sub-periods. While the objectives of modeling are changing obviously. At the beginning, researchers are eager to find a comprehensive model incorporating as many as factors to explain the whole shipping market. Then, efforts are paid to some specific shipping indexes of shipping market with more detailed settings and advanced techniques. Next, modeling objectives become more manifold. New concepts and individual decision factors are incorporated into the modeling technique. In recent modeling studies, new ideas and interesting insights are more welcomed.

Since most of the previous studies in shipping market economics are dealing with data, the econometrics method also takes a big portion. Specifically, GARCH model and its various extensions are always popular since its first appearance in 1996 (Kavussanos, 1996). However, the application of GARCH is evolving. At first, the GARCH is extensively adopted in explaining various shipping indexes volatility issues, like freight rate, ship price and freight futures. Then new influencing factors are added, like commodity futures, stock price and oil price. Furthermore, the GARCH has also obtained great attention in volatility spillover analysis in recent years. The active performance of GARCH is companied with continuous expansion of the model and incorporating new things. VECM model is also widely adopted similar to GARCH, especially in 2002-2007. The application of VECM is often together with the cointegration test and acts as a basic model for interpreting the long-run relationship between factors. In terms of linear regression, which appears only at the beginning and the end of our observation period, its application reflects the development direction of shipping market economics. In the beginning, the linear regression is mostly applied due to the limitation of available economic tools. However, with the development of econometrics in the capital market, more advanced economic tools like GARCH and VECM are entering shipping market and producing fruitful findings. As a result, linear regression is no longer viable. Recently, after 20 years of investigation, the research potentials of those economic tools are gradually declining. New topics and data sources are introduced into the shipping market. Compared to those advanced economic tools, which specialized in time series and with strict assumptions, linear regression has again shown its simplicity in dealing with unknown factors. The new topics and data sources such as AIS are supposed to bring new opportunities for shipping market economics research. Except for econometrics and modeling, qualitative analysis and review methods disappear after 2008, as shipping market economics are going through an expanding process and no systematic subject has been formed yet.

The overall trend for evolution of research methods is from wide to narrow then back to wide. At the exploring stage, four technique clusters exist. But only two clusters, GARCH and modeling, have succeeded to keep continuously active and developing. In 2002-2007 and 2008-2013, GARCH and modeling cluster incorporate more and more research methods into their group, but no new research technique cluster appears. Only after 2014, we can see that cointegration analysis is separated from GARCH, linear regression and logit model become independent from modeling cluster.

2.6.2 Future research directions

There is an obvious inconsistency between the trend of research topics and methods in shipping market economics. It challenges the common thought that the variety of topics should also induce various research methods. This implies the research field is going from technique-driven to idea-driven. In the exploring period 1973-2011, topics in shipping market economics are limited, yet researchers try different methods to investigate it. Then in 2002-2013 with the introduction of econometrics, especially tools in time series data, the research topics are growing significantly. Some time series data studies, like "spot freight rate", "freight rate" and "FFA", are able to be isolated from a big scope, such as "dry bulk" and "tanker market", and form their own topic clusters. However, at the same time, the variety of research methods is declining with only "GARCH" and "modeling" two big technique clusters left. In 2014-2018, the variety of research methods shows a rapid increase. Because new ideas are brought into the shipping market field, such as "investor sentiment" and "shipping investment". Some econometrics methods, for example "linear regression" and "logit model", which show advantages in dealing with unknown relationships among factors, again become popular. However, the topics also become wide spread and cannot form a valid topic cluster. As a result, only two topic clusters "volatility spillovers" and "freight rate" remain active.

For future research, idea-driven topics should be favored. Specifically, new concepts or insights from micro-level and individual behavior perspective, such as "sentiment factor" and "shipping investment", are expected to bring new potential for shipping market economics research. In terms of the research scope, "freight rate" as an important but underdeveloped topic, is a good field to start with. The inter-market relationships study represented by "volatility spillover" together with "tanker market" will still be active. Emerging topics related to "shipping investment" are also promising.

Chapter 3. Research Questions and Literature Review

Based on the future research directions suggestion in Chapter 2, two topics are selected to be further investigated. Compared with "volatility spillover" and "tanker market" with a high development, topics in the lower part of thematic map during 2014-2018 in Figure 2-5 leave more space for a deeper investigation. Therefore, the scope is located in "shipping investment" and "freight rate".

In recent researches in shipping market economics, micro-level or individual factors are often considered in modeling the market, probably the consequence of application of micro-level data. The personal characteristics or behavior could also become influential at the market level, if those characteristics or behavior show some similarities among a bunch of people. Thus, some insights from the behavioral perspectives are expected to be made.

Combining the above inspirations and talks with my supervisor and two creative researchers, two specific research topics are selected. That is the second-hand dry bulk transaction price and the dry bulk freight rate seasonality. This chapter will explain the two topics this research selected and conduct a literature review focusing two topics.

3.1 Second-hand ship transaction

In "shipping investment", the most direct investment should be the purchase of ships. Decision makers should first select between new-building ships and second-hand ships (Merikas et. al., 2008). Then they search information through brokers. After negotiating with sellers, the price can be finally decided. It is expected that the characteristics of seller and buyer in second-hand ship transaction could influence the transaction price. Following this premise, research objectives are explained and literature review is conducted.

3.1.1 Research background and objectives in second-hand ship price

Maritime transportation constitutes more than 80% of international trade by volume and more than 70% by value, using more than 96,000 oceangoing ships (UNCTAD, 2019). Ships are capital-intensive assets transacted in a global second-hand market with hundreds of millions of dollars in annual transaction volume. Alizadeh et al. (2017) argue that agents in the market are heterogeneous and can be categorised into those owning ships to utilize the transportation service that they provide (operators) and momentum-following speculators who care mainly about the profits gained from asset play. In the literature, second-hand ship price formation is attributed to both macro- and micro-economic factors. At the macro level, freight rates (Adland et al., 2006) and the sale and purchase (S&P) volume (Alizadeh and Nomikos, 2003; Syriopoulos and Roumpis, 2006) are typically found to be dominant factors. At the micro level, the influencing factors include the specifications of the ship, for example, DWT, age, and ship design (Adland and Koekebakker, 2007; Koehn, 2008). However, as argued and confirmed empirically by Adland et al. (2016) for the freight market, at the individual transaction level it is reasonable to argue that the characteristics of buyers and sellers (and their pairwise matching) influence prices. For any given second-hand vessel, there is only one seller and, at most, several interested buyers, akin to the micro-auction around the transportation of a single cargo in the freight market. Following on from the work of Alizadeh et al. (2017) and Adland et al. (2016), this research therefore proposes in this paper that the domicile of buyers and sellers in the second-hand market (and their matches) should affect second-hand prices in individual transactions. While it should ideally be investigated empirically at the company level, we note here that it is a common market practice among brokers in the second-hand market to obfuscate the identity of agents in reported sales, for instance, reporting only the nationality of buyers in such terms as “Greek interests”. Accordingly, this research has no choice but to consider one source of heterogeneity at the country level and investigate empirically whether investor domicile plays a role in explaining the second-hand ship price formation for individual transactions.

The domicile of buyers and sellers can affect prices through several mechanisms, but as a general framework, it is useful to think about asymmetries in funding conditions, market expectations, and aspects related to business culture and negotiations. In the literature (see, for example, Dimitratos et al., 2004; Pan, 2002), domestic market conditions such as currency exchange rates, loan interest rates, national regulations affecting international business, and social stability have shown to affect the performance of international companies. Stopford (2009) also mentions the potential influence of domestic regulations on costs and competition in the shipping industry. In terms of domestic economic conditions, we note that the financing of a second-hand ship transaction is highly dependent on bank financing, which is often local in nature due to personal relationships. Before the 2008 financial crisis, nearly 75% of the funding came from bank loans (Kavussanos and Tsouknidis, 2016). Tight domestic economic conditions can therefore increase the financing cost and level of taxation, thereby reducing the price that a buyer is willing to pay for an expected cashflow from the asset. Conversely, a strong domestic economy may lead to greater needs for maritime transportation services, particularly if domestic shipowners are given preference in carrying imported raw materials for strategic security reasons. Explicit or implicit government support or policies, such as state-owned banks providing generous low-cost financing or fleet renewal subsidies, will have the same effect. Based on such differences in market conditions, investors from different countries tend to form different market expectations even towards the same asset (French and Poterba, 1990).

During a transaction, the matching effect between the buyer and the seller can make the situation even more complex. The S&P process involves various steps, including the identification of suitable buyers or vessels, detailed negotiations, a physical vessel inspection, and inspection of certificates, and is usually assisted by a shipbroker. The information available to a shipbroker may not be comprehensive and relies heavily on the shipbroker's social network (Goldrein et al., 2013). As a result, ship sales transactions may be conducted on the basis of regional and personal links, which necessarily includes investor domicile and potentially a matching bias. Moreover, mutual trust is important in international negotiations, and it is well known that investors tend to choose trading partners with a degree of familiarity to avoid possible risks (French and Poterba 1991). Therefore, such a cultural selection bias could affect negotiations and prices in international transactions. Given the above factors, this research believes that investor domicile is fundamental in decisions regarding ship investment and acquisition.

This unobservable investor domicile effect on the second hand ship price has not been addressed in the extant literature. This study attempts to reveal the investor domicile effect. Specifically, this research adopts the seller and buyer countries as a proxy for asymmetric domestic market conditions and expectations. The matching effect between seller and buyer countries evaluates broker bias and the impact of trust. This contribution is important as it sheds light on behavioural factors in the S&P market. From a managerial perspective, this study provides quantitative evidences that the domicile of one’s transactional counterpart affects the ultimate transaction price of a vessel. The results put emphasis on the counterpart domicile selection during the negotiation stage.

3.1.2 Literature review on second-hand ship price

The volume of research related to second-hand ship pricing is less than that related to freight rates. Pruyn et al. (2011) reviewed the past 20 years of research and summarized the development of second-hand ship pricing models as moving from the macro to the micro level. A recent survey paper of Alexandridis et al. (2018) also reviewed the research development related to the second-hand ship markets.

Previous research on second-hand ship price formation focuses mainly on the macro perspective and can be categorised into two major categories. The first category is the modelling of second-hand ship prices jointly with freight rates in structural economic models (Hawdon, 1978; Beenstock, 1985; Beenstock and Vergottis, 1989; Adland and Jia, 2015). The second category is the study of price dynamics and macro relationships. Here, researchers are concerned chiefly with the efficient market hypothesis (Hale and Vanags, 1992; Glen, 1997; Kavussanos and Alizadeh, 2002; Adland and Koekebakker, 2004; Engelen et al., 2009), second-hand ship price volatility (Kavussanos, 1997), and price–volume dynamics (Alizadeh and Nomikos, 2003; Syriopoulos and Roumpis, 2006). Relationships between second-hand ship price and other macro-level variables such as new-building price and freight rate have been investigated. For example, Tsolakis et al. (2003) conducted a systematic analysis of the modelling of second-hand ship price and found that new-building and time charter rates had the greatest effect on second-hand ship price. Adland et al. (2006) tested the relationship between second-hand ship price and new-building price and freight rates during the drybulk boom market (2003–2005); their results similarly showed that second-hand ship prices are highly influenced by both new-building price and freight rates.

With the improved availability of transactional and technical data for ships, researchers have turned to the study of second-hand ship price formation at the micro level. Adland and Koekebakker (2007) applied a non-parametric approach to analyse bulk ship valuation. Through the cross-sectional analysis of individual sales of Handysize bulk carriers, three factors (DWT, age, and freight rates) are found to explain second-hand ship price. However, to better explain the real transaction price, additional ship-specific factors need to be taken into consideration. Using individual S&P data for chemical tankers, Koehn (2008) added more micro variables, such as the number of tanks, pump capacity, vessel design speed, engine horsepower, and IMO (International Maritime Organization) classification for tank coating. Koehn (2008) applied a semi-parametric method to explain second-hand ship price and showed that most of the micro variables had a significant impact on ship price formation except for the classification society and ice class.

There are some limitations in previous micro-economic studies of ship transaction prices, which we address in our work. From a methodological point of view, the non-parametric approach of Adland and Koekebakker (2007) can handle only a low-dimensional valuation model whereas the semi-parametric approach of Koehn (2008) assumes that key variables influencing the value of ships, such as vessel size, freight rate, and vessel age, are separable and additive. Though this solves the problem of having a sufficient number of variables, the assumption of separability is highly problematic. Clearly, a scrapping candidate with a limited remaining life will have a lesser benefit of a strong freight market than a newbuilding. Therefore the impact of age and freight rates, at the very least, must be estimated jointly. As pointed out by Adland and Koekebakker (2007), there are other numerous technical variables (e.g., vessel speed, fuel consumption, country of build) that may affect the value of a vessel. At the same time, those authors showed that the interplay between vessel age, freight market conditions, and vessel size is so complex that it is better represented by a non-linear valuation surface rather than a linear regression. Therefore this research solves this micro-economic study methodologically by accounting for the non-linear valuation variables in a first non-parametric regression stage and investigate the impact of additional variables in a second linear regression stage. Here, the residuals are further decomposed into ship-specific factors and the investor domicile effect through a fixed-effect model. We note that this type of two-stage approach is not uncommon in empirical work. For instance, Adland et al. (2017) estimate a market index in a first step, with further investigation of market drivers in a second step. Our main contribution is to propose and test the hypothesis that investor domicile impacts individual transaction prices through the mechanisms described above.

3.2 Freight rate seasonality

In "freight rate" research, many characteristics of freight rate have been extensively investigated. Yet the development of this topic has not seen much increase. For example, even in 2018, the stationarity problem of shipping freight rate is still under investigation (Kou et. al., 2018). This provides opportunities for some previous topics to be revisited plus new ideas and innovations.

This thesis re-investigates the seasonality issues in freight rate. Because of the rapid development of Chinese economy, the import volume of certain dry bulk commodities from China witnesses significant increase. As a result, the former seasonality pattern of freight rate could be influenced by the change in the demand side which is related to the behavioral patterns of industrial production in China.

3.2.1 Research background and objectives in freight rate

Seasonality in shipping freight rate markets was recognized and investigated rigorously for the first time by Kavussanos and Alizadeh (2001, 2002) and subsequently by Poblacion (2015) and Yin and Shi (2018). Seasonality in freight rates is a consequence of the seasonal demand for freight services. Dry bulk commodity transportation involves the major cargoes of iron ore, coal, grain, bauxite, alumina, and other minor bulks. The first three of these cargoes drive the dry bulk market. The production and export of iron ore and coal depend on the industrial activity of importing countries. In contrast, the export of grains, whose production depends largely on the weather, is usually based on the harvest season(s) of the exporting countries. The demand for freight services for these commodities exhibits seasonal behaviour (Stopford 2009), and thus it is expected that similar seasonal effects will be observed in dry bulk freight rate markets.

Kavussanos and Alizadeh (2001) quantified the seasonality of dry bulk freight rates with different charter lengths using monthly data for the period 1980 to 1996. They attributed the seasonality partially to the import activity of dry bulk commodities in Japan and Europe. However, recently the growth in China has spurred a demand for industrial commodities. Since China's entry into the WTO in 2003, the Chinese economy has grown substantially, leading to a higher demand for the transportation of dry bulk commodities, especially iron ore and coal, which are related to steel production and consequently to industrial production. According to UNCTAD Maritime Review (2019), China was the world's biggest importer of iron ore and coal in 2018, accounting for 71% and 19%, respectively, of the world's import volume of these commodities. This compares with 1996, when Japan and Europe accounted for most of the import volume of iron ore and coal, with China accounting for only 12% of the world iron ore trade volume (UNCTAD 1997). Therefore, this will distort the demand structure and seasonal patterns for dry bulk commodities. At the same time, industrial production in China appears to have different holiday patterns compared with other countries/regions such as Japan and Europe. For example, a decline in industrial output is typically observed in June and July in Europe (see Kavussanos and Alizadeh 2001), a feature that is unlikely to exist in China because there are typically no summer holidays for industries there.

The seasonality patterns of freight rates may be influenced by the aforementioned factors. In the present study, the seasonality in dry bulk freight rates is revisited in order to determine whether the importance of China in dominating world trade in the above-mentioned commodities has introduced a different pattern of seasonality in shipping freight rates. Furthermore, to identify different seasonality patterns, this research identifies a break point when the demand structure for freight services began to change. In the study, this research attempts to explain this change in demand structure from the perspective of the impact made by China. In summary, the purpose of this study is to consider whether the growing and substantial economic significance of China in world seaborne trade over the past two decades has had a significant impact on patterns of seasonality in shipping freight rates.

Identifying seasonality in freight rates can be beneficial for both ship owners and cargo owners in forecasting short-term trends, as well as in making decisions regarding fleet dispatch, lay-up, dry docking, and strategic contract planning, leading to better capacity management during freight rate peaks and troughs.

3.2.2 Literature review on freight rate seasonality

Univariate time-series models of seasonality are typically divided into two categories: deterministic and stochastic seasonality (see Hylleberg et al. 1990). Both deterministic and stochastic seasonality are commonly used in seasonality analysis. Franses et al. (1995) argued that it is necessary to distinguish between two seasonality patterns owing to possible spurious regression. Denning et al. (1994) identified deterministic seasonality in the freight futures BIFFEX series, using data for the period 1985–1989.

Kavussanos and Alizadeh (2001, 2002) applied the HEGY method developed by Hylleberg et al. (1990) and Beaulieu and Miron (1993) to distinguish between deterministic and stochastic seasonality in shipping freight markets. Those authors found deterministic seasonality in freight rates of dry bulk and tanker markets but did not find stochastic seasonality. Yin and Shi (2018) investigated freight rate seasonality in the container sector for the period 2004 to 2016, utilizing the China Containerized Freight Index, and found that seasonality in container freight markets is deterministic.

Poblacion (2015) applied spectrum analysis developed by Wei (2006) to test stochastic and deterministic seasonality in shipping time-charter equivalents in different routes of the dry bulk market for the period 2009 to 2014 and found stochastic seasonality in that market. A four-factor model (see Garcia et al. 2012), in which the seasonal component is treated as a stochastic factor, was then applied to model stochastic seasonality. However, as noted by Poblacion (2015), spectrum analysis must be applied with caution because of the potential estimation error. Furthermore, confirmation of stochastic seasonality is made by checking whether the peak in the spectrum chart is sharp or broad but without quantification, which places doubt on the results.

Besides the above papers on shipping freight markets, seasonality studies in other markets include that of Oglend and Asche (2015), who investigated cyclical non-stationarity in 16 world trade major commodity prices from 1976 to 2012. Instead of the common quarterly or monthly cycles, the seasonal unit root was tested at longer cycles (3 to 5 years). The results showed that stochastic seasonality became conspicuous in the long-run cycles. Vergori (2016) also found stochastic seasonality in the tourism volumes of four European countries for the period 1990 to 2014. A SARIMA model was adopted to model the time series and proved to have better forecasting performance. Montasser and Gupta (2016) noticed a potential break point in macroeconomic data from 1990 to 2013 and applied a new seasonal unit root test, allowing for an unknown break point in the data (Popp 2007) of industrial production of BRICS (Brazil, Russia, India, China and South Africa). Their results revealed that there is a seasonal unit root for China’s industrial production and that the break point is located at 2008.

Based on the aforementioned research into seasonality in shipping freight rates, the present study contributes to the literature by identifying the effect of China on seasonality, presumed to be a function of the growing significance of the Chinese economy in the world economy and, in particular, in shipping freight markets.

Chapter 4. Domicile Effect on Second-hand Ship Transaction

4.1 Introduction

The term "domicile" in this thesis refers to the common residence country of shipping companies, in which they raise their funding, follow the regulations and benefit from regional policies. This chapter investigates the contribution of investor domicile effects to second-hand bulk transaction price formation. This research applies a two-stage regression approach, first capturing the effects of vessel age and market conditions in a non-parametric model and, in a second stage, adapting fixed-effect models to investigate investor domicile effects and ship-specific factors.

4.2 Methodology in Second-hand ship Transaction

The methodology adopted in second-hand ship transaction is an extension of that of Adland and Koekebakker (2007) and Adland et al. (2016). Specifically, inspired by the evidence of non-linearity and joint (non-separable) impact of vessel age and freight rates in Adland and Koekebakker (2007), this research implements a first-stage non-parametric regression accounting for these variables. Then, in a second stage, this research implements the fixed-effect model outlined in Adland et al. (2016) to assess the further impact of the different ship-specific factors as well as investor domicile effects. This research extends these two studies to a more robust approach, which constitutes our main methodological contribution.

This research uses the time charter freight rate rather than a second-hand ship price index to account for the impact of market conditions. As pointed out by Adland et al. (2017) concerning the inclusion of market indices, “these indices pick up composition effects in addition to market conditions”, and so the inclusion of such an index would result in an endogeneity problem. Besides the freight rate, the ship age at the time of transaction is also included in the first-stage analysis. According to Stopford (2009) and Adland and Koekebakker (2007), the relationship between ship price and age can be non-linear. Moreover, the impact of market conditions will also vary with vessel age, and this interaction effect is not easily incorporated into the traditional linear model. Therefore, market effects are represented by both freight rate and ship age in our non-parametric model:

$$TP_i = V\left(Freight_i, Age_i\right) + \varepsilon_{1i} \quad (4\text{-}1)$$

In Equation (4-1), TP_i is the transaction price for each transaction i, $V(\text{X})$ is the non-parametric function based on Multivariate Density Estimation (Adland et al. 2007), $Freight_i$ is the one-year time charter (TC) rate at the time of transaction i, and Age_i is the vessel age in transaction i. The term ε_{1i} is the error term.

In our second-stage regression, the estimated error term ε_{1i} is further decomposed into ship-specific factors and investor domicile effects using three different linear model specifications.

Our first specification is an OLS (Ordinary Least Squares) regression model that includes the (time-invariant) ship-specific variables. The model is expressed as

$$\varepsilon_{1i} = \alpha_0 + \alpha_1 DWT_i + \alpha_2 SP_i + \alpha_3 MF_i + \alpha_4 HP_i + \sum_j \beta_j DBC_{i,j} + \varepsilon_{2i} \quad (4\text{-}2)$$

In Equation (4-2), DWT_i is the Dead Weight Tonnage, SP_i is the design speed for transaction i, MF_i denotes the main fuel consumption (tons per day), HP_i is the horsepower, $DBC_{i,j}$ is the dummy variables for different builder countries j for the ship sold in transaction i, and ε_{2i} is a white noise error term.

Similar to Adland et al. (2016), this research considers the impact of buyers and sellers on prices, though the characteristics of agents in the present study are proxied by their country of domicile. Based on the discussion in the introduction, we believe that the (behavioural/cultural) characteristics of buyers and sellers can be reasonably proxied by the country of domicile. However, we also note that buyer company identity is not provided in the data in many cases and may simply be stated as, for instance, "Greek interests".

In practice, the characteristics of sellers and buyers will be affected by some exogenous variables, which means that simply adding seller or buyer dummy variables into the model may cause multicollinearity. Therefore, this research applies a fixed-effect model to account for the seller and buyer country effects in individual transactions. The primary model specification is:

$$\varepsilon_{1i} = \alpha_0 + \alpha_1 DWT_i + \alpha_2 SP_i + \alpha_3 MF_i + \alpha_4 HP_i + \sum_j \beta_j DBC_{i,j} + \gamma_s + \delta_b + \varepsilon_{2i} \quad (4\text{-}3)$$

In Equation (4-3), seller and buyer fixed effects are defined by γ_s and δ_b, respectively.

In addition to seller and buyer country effects, Adland et al. (2016) added a third effect: the matching effect between buyers and sellers. This effect was first introduced by Woodcock (2008) to analyse the wage determinants of workers. The relationship between firms and workers is similar to that of sellers and buyers. According to Gobillon et al. (2013), the matching effect between sellers and buyers actually measures the match and the sampling error, which is important in explaining the variance composition of the dependent variable.

The matching effect here refers to the impact of a combination between investors' country of domicile. Because this research treats the seller and buyer country effects as a fixed effect, the matching effect should also be time invariant. The matching effect can be analysed by the one-dimensional fixed-effect model given by:

$$\varepsilon_{1i} = \alpha_0 + \alpha_1 DWT_i + \alpha_2 SP_i + \alpha_3 MF_i + \alpha_4 HP_i + \sum_j \beta_j DBC_{i,j} + \Theta_{sb} + \varepsilon_{2i} \quad (4\text{-}4)$$

where Θ_{sb} is a fixed-effect factor that incorporates both the seller–buyer country effect and the matching effect. According to Adland et al. (2016), after obtaining the results for the fixed effect Θ_{sb}, the estimated fixed effect Θ_{sb} can be further decomposed into

$$\Theta_{sb} = \alpha_0 + \gamma_s + \delta_b + \theta_{sb} \quad (4\text{-}5)$$

In Equation (4-5), γ_s is the estimated fixed effect of sellers, and δ_b is the estimated fixed effect of buyers. The matching effect θ_{sb} is supposed to be orthogonal to both seller effect γ_s and buyer effect δ_b, and thus the matching effect θ_{sb} can be obtained as the residual of a two-dimensional fixed-effect regression of Equation (4-5).

4.3 Data

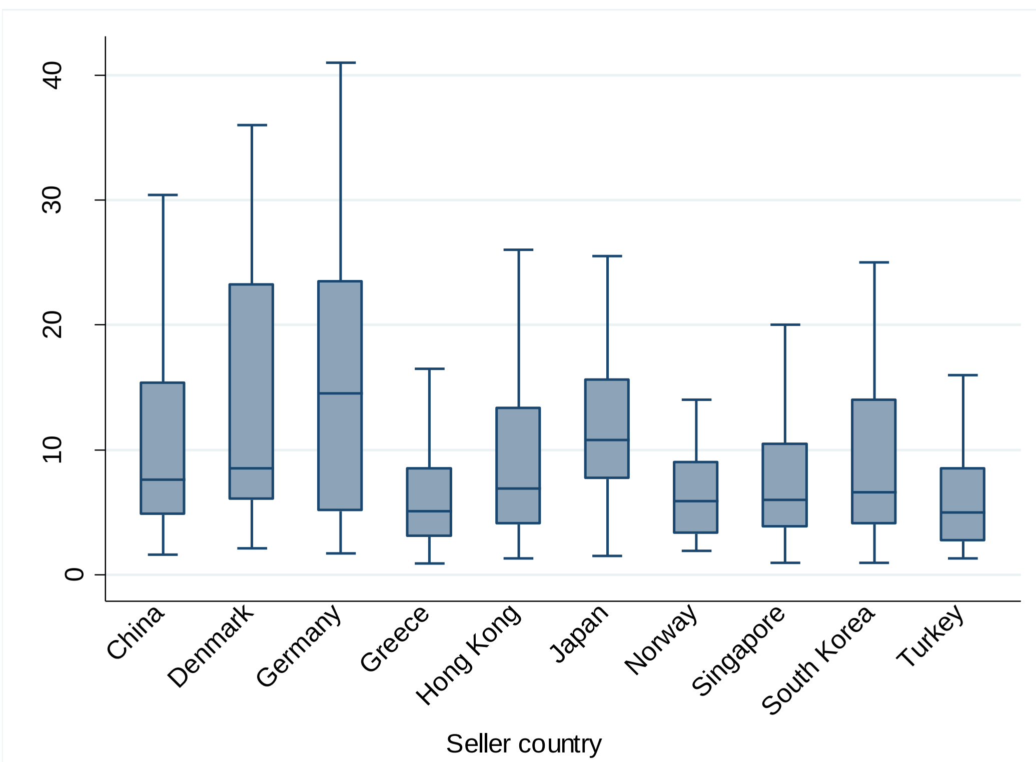
The dataset used in this study was obtained from Clarkson Research (2016)[5]. Many previous studies were also based on Clarksons' second-hand ship price data, and some of previous studies are discussed in the literature review section. However, unlike previous studies, which analyze second-hand data as panel data, in this study, this research treats the data as cross-sectional data. To be more specific, in the first stage, the sale price is regressed on its corresponding market freight rate and ship age. The raw data of freight rate is a time series data, and observations of freight rate were recorded according to the transaction date. The freight rate data are not continuous over time. Repeated transactions of one ship are observed. However, because the record showed that the time periods between consecutive transactions of same ships are longer than one year, repeated transactions are regarded independent in the analysis. When conducting the analysis at the second stage, the dataset is a cross-sectional data because all the factors in second-stage do not vary over time (DWT, design speed, main fuel consumption, horse power, ship builder and domicile effect). One advantage of cross-sectional data is that, though for certain seller buyer country the transaction date is unevenly distributed along the time line, the country effect can be estimated without bias. This research has repeated the whole analysis after deleting repeated transactions and confirmed that the issue of repeated transactions does not violate the assumption that observation of transactions are independent of each other.

The raw dataset contains 2,931 transactions for Handysize bulk carriers from 5 January 1996 to 31 March 2016. This segment was chosen because the second-hand market for this vessel type remained relatively liquid throughout the period and the vessel type has a geographically wide ownership and sailing pattern. The data cover various specifications for each ship transaction, specifically, transaction price, age, DWT, design speed, main engine fuel consumption, horsepower, and builder country. The characteristics of sellers and buyers are represented by the country in which they are domiciled. Because for the buyers' specification, most of the observations do not specify the company name of buyers but instead provide a country identification/definition such as "Greek interests". If this research was to use company name to denote the characteristics of buyers, about 1,400 observations would be dropped (in which "Chinese interests" accounts for 222, "Greek interests" account for 394, and "undisclosed

[5] Prices are collected for various sizes and ages of vessels for the main vessel types and relate to market sales where these have taken place. Source: https://www.clarksons.net/archive/research/archive/SNM/SIW_SNM.pdf

interests" account for 307), leaving fewer than 1,000 observations. As a compromise, this research proxies the characteristics of sellers and buyers by their country of domicile. Figure 4-1 illustrates the average transaction price for top-10 most frequent seller and buyer countries. We can observe that different countries have different transaction price distributions. Even for same country, it shows different price distributions when it acts as a seller and a buyer. Other factors such as vessel name, IMO number, vessel fuel type, main engine speed (RPM), engine type, number of holds, number of hatches, and gear summary are available but are not included in the final model. The monthly one-year TC rate data for Handysize bulk carriers were obtained from Shipping Intelligence Network. Although the sales data are recorded on a particular day, the match between freight rate and transaction price is based on the month of the transaction.

(A) Transaction price of top-10 seller countries



(B) Transaction price of top-10 buyer countries

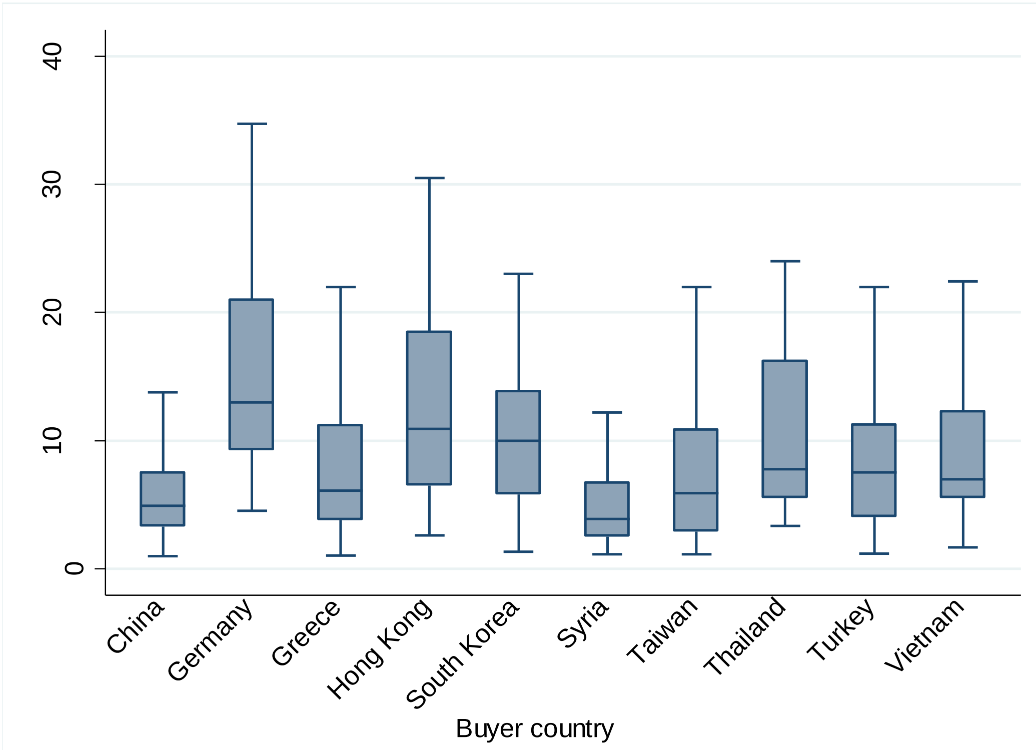


Figure 4-1. Average transaction price of top-10 most frequent seller and buyer countries

The raw dataset of 2,931 observations was cleaned as follows. In terms of transaction price, a total of 193 observations with missing values of transaction price were deleted along with outliers. Transactions denominated in a different currency from USD (such as RMB) were dropped. In terms of buyer country, about 659 observations labelled as "Unknown" were deleted from the observations. For seller country, 71 missing values were deleted along with 142 observations labelled as "Unknown". The remaining 1,715 observations were retained for the analysis. Table 4-1 presents the descriptive statistics of the variables.

Table 4-1. Descriptive statistics of characteristics of second-hand ships

	Mean	Max	Min	Std. Dev.	No. Obs
Price (USD million)	9.07	53.90	0.90	7.57	1,715
Freight rate ($/Day)	12,942	40,800	4,625	7,938	1,715
Age (years)	18.252	40.770	0.274	7.401	1,715
DWT (1,000 tonnes)	28.591	42.208	10.106	6.242	1,715
Speed (knots)	13.931	17.750	10.000	0.972	1,709
Main fuel consumption (tonnes per day)	25.2	49.3	11.5	6.8	1,588
HP (1,000 horse power)	9.082	18.700	3.300	2.029	1,715

Japan is the dominant builder country in our transaction database with 75% of all observations, followed by China (6%), South Korea (4%), and others (15%). Accordingly, this research includes the dummy variables "DJAPAN" representing the builder country of Japan, "DCHINA" denoting the builder country China, and "DOTHER" representing the residual builder countries, with South Korea as the benchmark.

The 10 most common buyer and seller countries are listed in Table 4-2. For "seller country", altogether 64 countries are represented, with the top 10 representing 73.27% of the total observations. For "buyer country", the top 10 countries together account for 79.01% of the total observations (57 countries). Among both seller and buyer countries, Greece has the highest number of active investors in the market.

Table 4-2. The top 10 most frequent seller countries and buyer countries

Seller country	Frequency	Average price (M$)	StdDev	Buyer country	Frequency	Average price (M$)	StdDev
Greece	506	7.05	5.98	Greece	624	8.85	7.75
Japan	276	12.16	6.90	China	276	6.63	5.55
China	104	11.08	9.07	Turkey	105	8.41	5.78
South Korea	89	9.11	7.07	South Korea	64	11.47	9.26
Germany	66	16.10	12.42	Syria	61	5.43	4.78
Turkey	47	7.07	5.72	Vietnam	53	9.92	7.09
Singapore	46	9.16	8.78	Germany	48	15.32	8.21
Hong Kong	45	10.06	8.59	Taiwan	44	7.48	5.79
Denmark	39	13.61	10.04	Hong Kong	42	14.07	9.99
Norway	39	8.18	9.07	Thailand	38	10.33	6.26
Others	458			Others	360		
Total	1,715			Total	1,715		

Table 4-3 provides a summary of matches between "seller country" and "buyer country". The top 10 matches of "seller country" and "buyer country" represent 34% of the total matches. Transactions with Greek interests on both sides are the most common, accounting for 11% of the total activity. The number of matches between same country is 304, accounting for 18% of the total matches. According to Harrell and Frank (2015), 10-20 observations per parameter is enough. In this work, all the top 10 seller and buyer countries have the observations more than 38. The results of domicile effect should be reliable.

Table 4-3. Top 10 frequent matches between seller country and buyer country

Matches between seller country and buyer country	Frequency	Percentage (%)
Greece–Greece	189	11.02
Japan–Greece	103	6.01
Greece–China	99	5.77
China–Greece	36	2.10
China–China	33	1.92
Germany–Greece	28	1.63
Greece–Syria	27	1.57
South Korea–Greece	26	1.52
Japan–China	25	1.46
Greece–Turkey	23	1.34
Others	1,126	65.66
Total	1,715	

4.4 Analysis Results

The non-parametric model adopted in the first stage of this study is based on kernel density estimation. Kernel density estimation aims to explain the relationship among factors directly from the data. Through characterising the joint distribution of transaction price versus market freight rate and ship age, the relationship function can be estimated by minimizing the weighted residual pricing errors. The weight function incorporates both a multivariate probability density function (kernel) and a bandwidth matrix. For kernel density estimation, the selection of bandwidth decides the performance of the kernel density estimator and is more important than the choice of kernel (Turlach, 1993). Adland and Koekebakker (2007) advised that the selection of bandwidth is a trade-off between the bias and increased variance of the estimator. Too small a bandwidth can result in over-fitting the data and increases the volatility, whereas too large a bandwidth smooths the estimator at the cost of possible bias. Here, this research sets the bandwidth at 10% of the historically observed range of the variables, equivalent to 4 years for vessel age and $3,600/day for the freight rate.[6]

The non-parametric regression results yield an R-squared value of 0.857 with the fixed bandwidth type and local-constant kernel regression estimator. The estimated transaction price is illustrated in Figure 4-2.

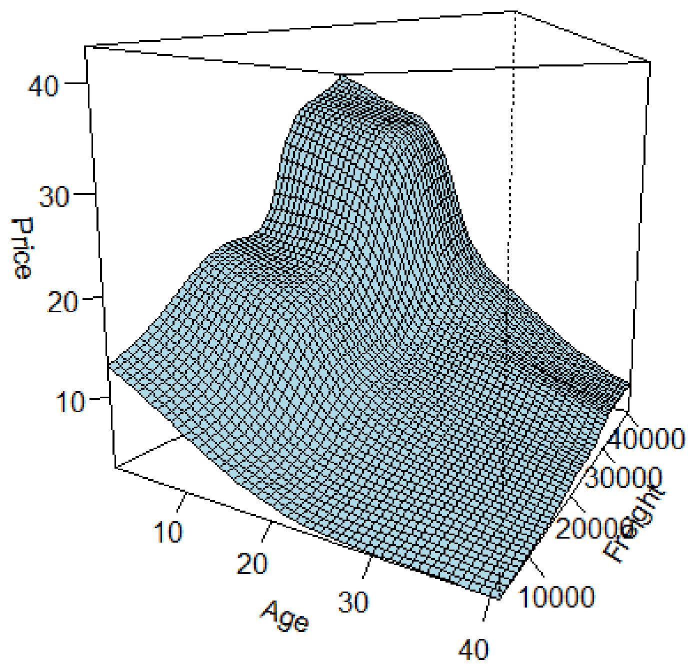


Figure 4-2. Estimated transaction price using the non-parametric regression model

The resulting vessel valuation surface in Figure 4-2 reflects some traits that are largely expected. Firstly, vessel values decline with increasing age, reflecting lower remaining lifespans and higher operating costs, all other things being equal. Secondly, vessel values increase with increasing freight rates. Thirdly, vessels are written down to scrap value more quickly in a poor freight market than in a strong freight market. Interestingly, there is evidence of considerable non-linearity in both dimensions, possibly reflecting a different speed of mean reversion in freight

[6] A more scientific approach using least square cross validation resulted in bandwidths that were obviously too low. Using 10% ensures a continuously declining vessel value surface as a function of increasing age and lower freight rate.

rates at low and high market levels respectively, as previously shown by Adland and Cullinane (2006). However, we note that the apparent levelling off for young vessels at very high freight rates could be an artificial construct of a low number of observations in this corner (there are only 19 observations for vessel age of <10 years and freight rate of >$30,000/day). The overall R-squared is high at 0.857, which means that this vessel valuation surface—which does not account for the heterogeneity in vessel technical specifications and investor domicile—dominates in explanatory power.

Next, this research decomposes the residuals from the non-parametric model further by adding ship-specific factors and investor domicile effects in a linear regression. Ship-specific factors are assumed to be exogenous and linearly related to the residuals, whereas investor domicile effects are treated as fixed effects.

This research specifies three different regression models. The first is a basic OLS regression without any fixed effects. The second contains "seller country" and "buyer country" fixed effects. The third model includes "seller country" and "buyer country" fixed effects as well as the matching effect between them. Table 4-4 presents the regression results for the three linear models.

Table 4-4. Regression results for ship-specific and investor domicile effects

Exogenous Variables	OLS regression		Fixed effect		Matching effect	
	Estimated Coef	P value	Estimated Coef	P value	Estimated Coef	P value
DWT	0.213***	0.000	0.222***	0.000	0.210***	0.000
Speed	0.301***	0.001	0.276***	0.003	0.304***	0.002
Main fuel consumption	−0.142***	0.000	−0.127***	0.000	−0.134***	0.000
HP	−0.0277	0.638	−0.0374	0.542	0.0161	0.805
DCHINA	0.105	0.812	0.282	0.550	0.693	0.176
DJAPAN	0.226	0.525	0.341	0.375	0.577	0.166
DOTHER	−0.172	0.658	−0.0827	0.845	−0.0253	0.957
R-squared	0.190		0.256		0.422	
No. obs.	1,588		1,588		1,588	

Note: *** represents a significance level of 1%, ** of 5%, and * of 10%.

The statistically significant variables for all three models are the same. As expected, DWT is positively related to the transaction price, reflecting the economies of scale and larger capital investment of a bigger vessel. Design speed measures the performance of the ship and is positively related to the transaction price. A higher main engine fuel consumption reflects a less energy-efficient vessel, all other things being equal, and reduces the vessel value. The remaining variables are not significant. The non-significance of builder country may be due to the large market share of ships built by Japan (75%).

The R-squared value for the first OLS model is only 0.190, which indicates only a small portion of information in the dependent variable can be explained by ship specific factors. When seller country and buyer country effects are added to form the fixed-effects model, the R-squared increases to 0.256. Adding the matching effect in the third model increases the R-squared further to 0.422, suggesting that this matching effect is important. Because there are over 60 countries for the seller–buyer matching effect, listing them one by one is inefficient and unnecessary. Here, this research illustrates the estimated fixed effect only for the top 10 seller–buyer country matches as listed in Table 4-3.

Figures 4-3, 4-4, and 4-5 show the estimated fixed effects for the top 10 seller countries, top 10 buyer countries, and top 10 respective country matches. Figure 4-3 and 4-4 show the estimated country fixed effect. The vertical axis (up to down) is in the descending order of number of observations of each country. However, the country fixed effect shows no tendency to become stronger or weaker (up to down). Buyer or seller fixed effects refer to the impact on vessel values from having a buyer or seller with a particular domicile, while the matching effect represent the impact of a particular country pair. In all cases, the effect can be added to the dependent variable so, for instance, if the fixed effect value of Greece as seller country is -0.09, then the ship sold by Greek ship owners tend to be 0.09 million USD lower, all else equal. We note that the domicile effects represent the long-term average impact.

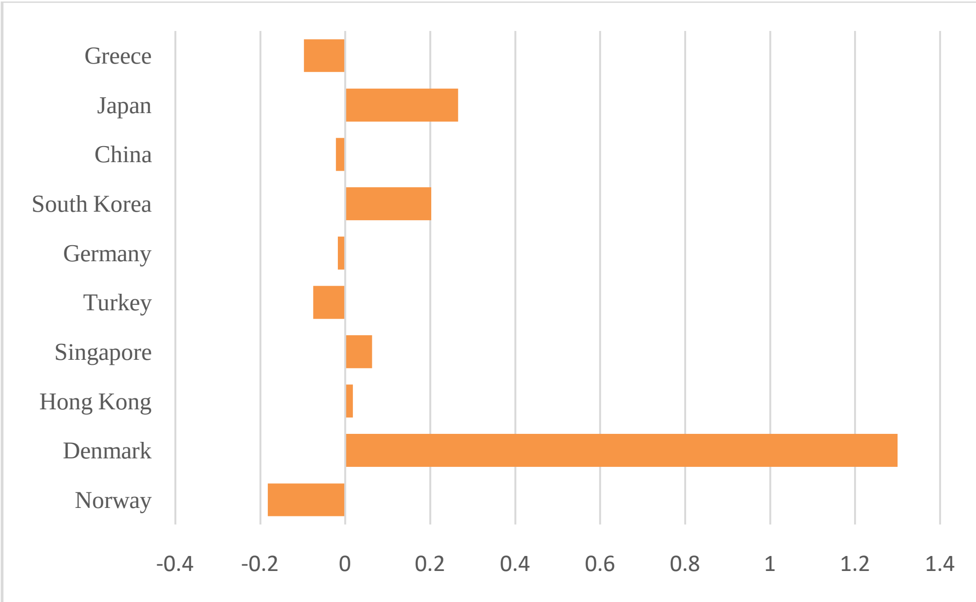


Figure 4-3. Fixed effect of seller country ($m)

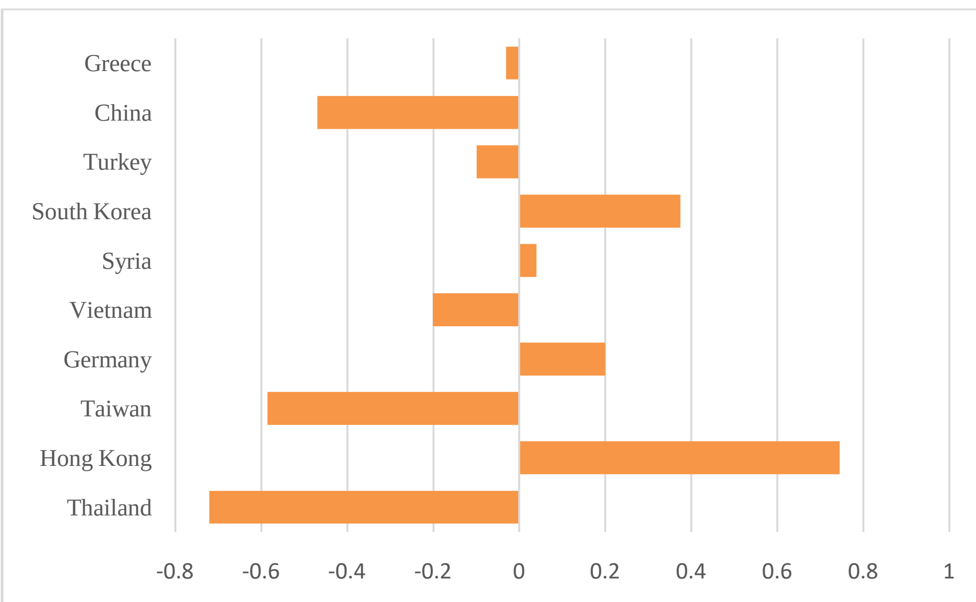


Figure 4-4. Fixed effect of buyer country ($m)

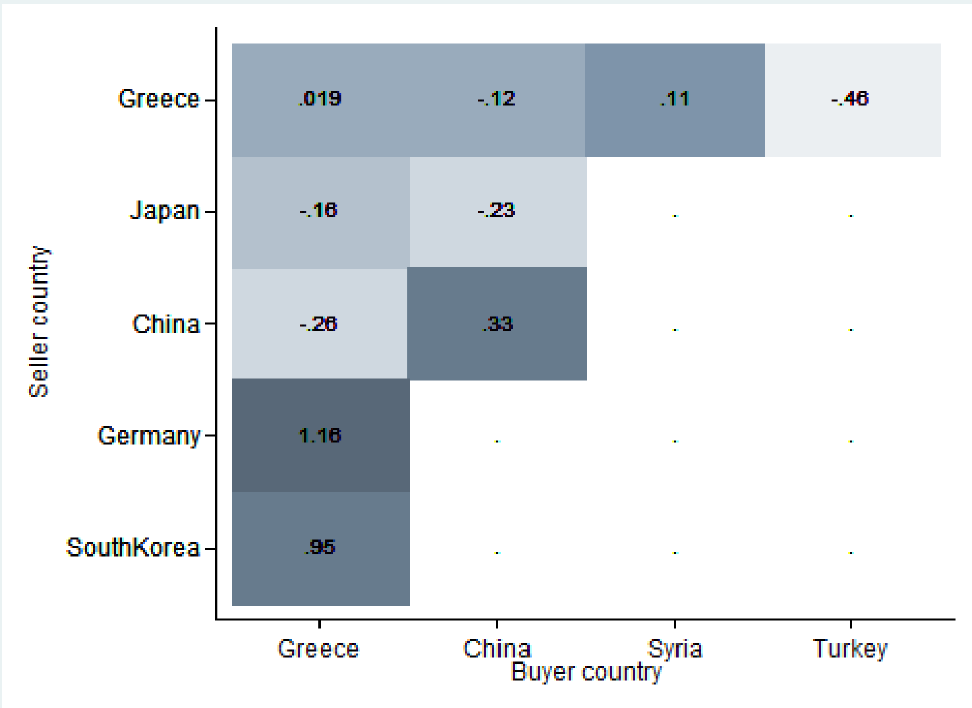


Figure 4-5. Fixed effect of matching between seller country and buyer country ($m)

As with any fixed-effect model, although we can observe that important differences exist in transaction prices depending on the buyer and seller country (and their match), the model does not tell us much about the causal relationships leading to the results. While it is tempting to consider the relative strength of the countries' economies as the main explanatory factor (e.g., general Asian economic strength vs Greek financial crisis post-2008), such relationships would have changed over the time period. Accordingly, since our estimates measure average effects throughout the sample period, this can only be part of the reason. Unfortunately, the relatively low number of transactions in the final sample does not allow us to examine subsamples of shorter time periods.

However, when comparing the results in Figures 4-3 to 4-5 with the transaction frequency of a country's investors (Tables 4-2 and 4-3), one general trend becomes clear: when proxied by their country of domicile, investors that enter the market less often are generally subject to larger effects on valuation. Note, for instance, the difference between German and Japanese sellers in their transactions with Greek owners. The matching effect between Germany–Greece is 1.16 with a transaction volume of 28, whereas the matching effect between Japan–Greece is only –0.16

with a transaction volume of 103. Intuitively, this makes sense and is aligned with the argument that more active investors have better access to market information and better negotiating power. It may also reflect the reach and information network of the local broking community. In addition, more transactions (matches) between two countries' investors seem to affect the magnitude of the matching effect, possibly by improving mutual trust. This is particularly obvious where both the buyer and seller are of the same nationality (e.g., Greece). The results illustrate the impact of such unobservable national or behavioural traits on vessel transaction prices in a quantitative way.

To better illustrate the importance of such unobservable investor domicile effects in the pricing of individual vessel transactions, Table 4-5 presents the decomposition of variance comparing the relative explanatory power of the ship-specific (technical) variables, country fixed effects, and matching effect.

Table 4-5. Variance decomposition of the dependent variable in fixed-effect model

Exogenous Variables	OLS regression		Fixed effect		Matching effect	
	Covariance	Weight	Covariance	Weight	Covariance	Weight
Ship-specific factors	1.671	19.0%	1.694	19.3%	1.635	18.6%
Seller effect			0.298	3.39%	0.300	3.41%
Buyer effect			0.258	2.93%	0.261	2.97%
Matching effect					1.514	17.2%
Residual	7.124	81.0%	6.544	74.4%	5.085	57.8%
Total	8.794	100.0%	8.794	100.0%	8.794	100.0%

The weight of ship-specific factors is basically the same among the three models (19%). After the seller and buyer effects are added, the share of the residual decreases. The addition of the matching effect in the third model further improves the explanatory power of the model. The investor domicile effect altogether accounts for one-quarter of the variance in our second-stage (micro-level) model. Importantly, this research shows that the domicile matching effect is of similar importance to the ship-specific variables (17% vs 19% in the most comprehensive model). This highlights that investors should pay more attention to the characteristics of their counterpart in S&P transactions.

4.5 Chapter Conclusions

This study examined the factors influencing ship transaction prices at both the macro and micro levels. Using individual ship transaction data, this research investigated the impact of market conditions, ship-specific factors, and investor domicile effects on transaction price. At the macro level, the market effect, which is denoted by freight rate and vessel age, accounts for most of the variance (85.69%) in transaction prices. When this research further investigates the drivers of the residual at the micro level, ship-specific factors and investor domicile effects are of similar importance (about 20%). Within the investor domicile effects, the matching effect between countries is particularly important. Within ship-specific technical variables, DWT, design speed, and main engine fuel consumption are statistically significant and likely to be considered in individual transactions. Other factors, such as horsepower and builder country, tend not to influence the transaction price significantly.

The results from this study empirically confirm the importance of investor domicile effects on second-hand values in individual ship transactions. This research argues that investor domicile represents an appropriate proxy for the cultural traits of investors as well as for the impact of domestic economic conditions on funding costs and market expectations. This research finds that investor experience, proxied by transaction volume between country pairs, influences transaction prices and argue that this is a reflection of information access, trust, and negotiating power.

Our analysis contributes to bridging a gap to the emerging literature on heterogeneous agents in the shipping and their impact on micro-level pricing. We acknowledge that the use of investors' domicile neglects the heterogeneity among different shipping companies within any one country, which may result in a bias in the fixed-effect analysis. Addressing the heterogeneity among shipping companies would significantly complicate the analysis. However, these data are limited in the field, and so more disaggregated analysis might be challenging for time being. This could be a potentially fruitful direction for future research.

Chapter 5. Seasonality Issues in Dry Bulk Freight Rate

5.1 Introduction

This chapter examines the seasonality of freight rates across different ship sizes and time periods in dry bulk market. This research applies the stochastic seasonality test to identify the potential seasonal unit roots in monthly freight rate. This research also considers the influence of Chinese economy on the dry bulk commodity market, which potentially distorts the seasonality patterns of freight rate.

Lu and Li (2009) examined the China's contribution to the global incremental consumption growth for commodities and ocean shipping services. The results confirm that by 2007, the international commodity prices fluctuation is no longer independent of China's own industrial activities. Since the prices of major dry bulk commodities are closely related to some freight rate index (Tsioumas and Papadimitriou, 2018), the China effect should potentially influence the seasonality patterns of freight rate in the major dry bulk commodity market.

5.2 Methodology in Freight Rate Seasonality

Seasonality in time-series data can take two forms: purely deterministic, due to fixed seasonal effects; and stochastic, due to the existence of seasonal unit roots (Hylleberg et al. 1990). Seasonal patterns are most often calculated using monthly data. As with most previous analysis, more frequent data bring more noise and erratic results.

Deterministic seasonality assumes that the seasonal effect in each observation period remains the same over time. Seasonal dummies are independent of each other, and thus the equation investigating it takes the following form:

$$\Delta X_t = \alpha_0 + \sum_{i=1}^{11} (\alpha_i + \mu) D_{it} + \varepsilon_t \tag{5-1}$$

Because monthly data are adopted here, Equation 5-1 includes 11 seasonal dummy variables, D_{it}, with December as the benchmark. ΔX_t is the first monthly difference of the investigated freight rate series. The time-charter freight rates of different lengths of time are utilized. The unit root is shown to exist through the Dickey-Fuller test. By taking the first difference of the freight rate, the data become stationary. ε_t is a white-noise error term. α_i is the estimated coefficient measuring the relative effect of each month compared with the benchmark month. Furthermore, to interpret the seasonal coefficients as effects over the monthly average instead of the benchmark month, a constant μ is added to each seasonal coefficient. As defined by Suits (1984), $\mu = -\sum_{i=1}^{11} \alpha_i / 12$. Therefore, the seasonal effect of all months can be determined. The variance of the benchmark month can be calculated through the variance-covariance matrix of α_i in Equation 5-1 (for details, see Kavussanos and Alizadeh 2001).

However, without identifying whether there is stochastic seasonality, applying deterministic seasonality directly may cause spurious regression with high R-squared values (Franses et al. 1995). This is caused by the seasonal unit root, which assumes the parameters to be periodic. To model the unit root, Hylleberg et al. (1990) proposed seasonal filters to allow different seasonal unit roots to be tested in one model. Beaulieu and Miron (1993) further developed the model to fit monthly data. Thus, stochastic seasonality may be tested for by using Equation 5-2:

$$\Delta_{12} X_t = \alpha_0 + \lambda t + \sum_{i=1}^{12} \beta_i Y_{i,t-1} + \sum_{j=1}^{11} \alpha_j D_{\mathrm{j},t} + \sum_{k=1}^{p} \varphi_k \Delta_{12} X_{t-k} + \varepsilon_t \tag{5-2}$$

The operator $\Delta_{12} = (1 - L_{12})$, where L is the back-shift operator, meaning the difference between X_t and X_{t-12}. Besides the seasonal dummy $D_{\mathrm{j},t}$ and a constant α_0, three terms are added. A time trend, denoted as λt; seasonal filters, represented by $Y_{i,t-1}$; and an error correction lagged value term $\Delta_{12} X_{t-k}$, which is included to eliminate possible residual autocorrelation. The value selection of order p is based on the Akaike information criterion, and the Schwarz information criterion gives a similar lagged order. A white-noise error term is denoted by ε_t.

The seasonal filter $Y_{i,t-1}$ is actually a complex polynomial that allows tests for unit roots at some seasonal frequencies without holding unit roots at all seasonal frequencies (for details, refer to Beaulieu and Miron 1993). The criteria to reject all the seasonal frequencies are $\beta_i \neq 0$ when $i = 2$ and one or more members of each of the sets {3, 4}, {5, 6}, {7, 8}, {9, 10}, and {11, 12} are not equal to zero for the joint F-test $\beta_i = \beta_{i-1} = 0$. If $\beta_1 = 0$, we cannot reject the presence of a non-seasonal unit root. Alternatively, if $\beta_2 = 0$, we cannot reject the presence of a seasonal unit root. In practice, this process is realized through HEGY add-in[7] on EViews (edition 9.0).

The regression results of Equation 5-2 are helpful for determining whether there are seasonal unit roots. The coefficients of seasonal dummies in Equation 5-2 are not appropriate for measuring the seasonal effect, even after removing the seasonal filters, because the dependent variable is the 12th difference of the series rather than monthly growth, and too many independent variables significantly decrease the degrees of freedom (Kavussanos and Alizadeh 2002). If the seasonal unit root is rejected at all frequencies, then it is appropriate to apply the deterministic seasonality model as in Equation 5-2. If stochastic seasonality is not rejected, alternative methods should be considered to model the time-series data, such as SARIMA (Seasonal Autoregressive Integrated Moving Average, see Vergori 2016) and factor models (see Poblacion 2015).

5.3 Data

Monthly 6-month time charter rate (6m TC), one-year time-charter (1y TC) rates and three-year time-charter (3y TC) rates for different size dry bulk carriers were collected from Clarksons' SIN (Shipping Intelligence Network). Four sizes of dry bulk carriers were considered: Capesize (150k DWT), Panamax (65k DWT), Handymax (45k DWT), and Handysize (32k DWT). Due to the data availability on SIN, this research includes average trip-charter rates for Panamax and Handymax bulk carriers only.[8]

The major commodities for dry bulk carriers are iron ore, coal, grains, bauxite, and alumina. As noted in Kavussanos and Alizadeh (2001), the cargoes for Handymax and Panamax vessels can be widely diversified, including all major and minor dry bulk commodities. The freight demand

[7] http://forums.eviews.com/viewtopic.php?t=13284
[8] The time series of trip charter rate of Capesize and Handysize bulk carriers begin in 2009.

for grains depends on the harvest season, as the transportation of grains should be timely because critical storage conditions are needed to keep the grains fresh. Apart from grains, Handysize bulk carriers are also utilized to transport minor dry bulk commodities (agribulks, sugar, fertilizers, metals and minerals, steel products, and forest products). In contrast, the freight demand for iron ore depends on the economic activity of importing countries. The production and storage of iron ore are manual set. It is more cost-effective to utilize larger ships in the transportation of iron ore, and therefore Capesize bulk carriers are mainly engaged for iron ore transportation. Seasonality related to these commodities should significantly influence the seasonality of freight rates.

Descriptive statistics of the data used in this study are presented in Table 5-1. In many occasions, the observation periods of different sizes of ships should be identical to make sure the results are comparable to each other. However, due to the data availability on SIN, the final data only has similar starting months but with different ending months. As Table 5-1 shows that the volatility of larger ship sizes and longer time-charter lengths is higher according to the standard deviation values. All the time series are non-stationary at the 5% significance level.

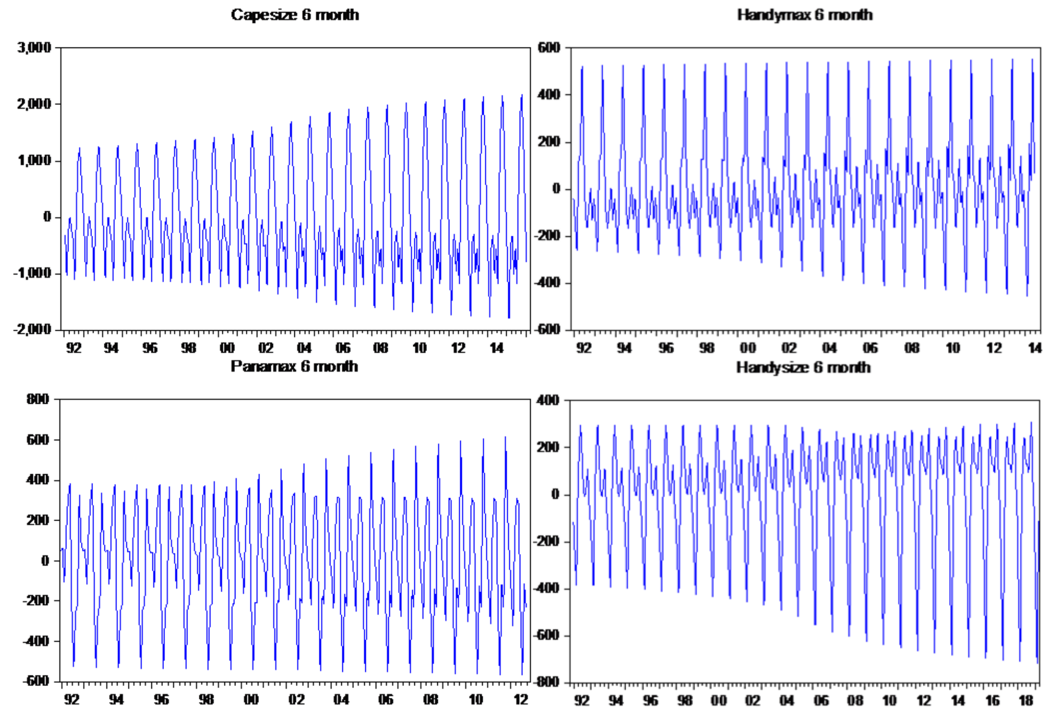
In order to allow for a more straightforward illustration of the seasonal component in the time series data, STL (Seasonal and Trend Decomposition using Loess) method is applied first to decompose the data. The seasonal components of time charter rate with different charter periods are illustrated in Figure 5-1. The seasonal components of trip charter rate are plotted in Figure 5-2. As shown in Figure 5-1 and Figure 5-2, the seasonal components of freight rates data are gradually changing from 1991 to 2016. The changing process is located around 2000 to 2008. This study attempts to investigate this seasonal change from the perspective of China effect.

Table 5-1. Descriptive statistics of dry bulk time-charter rates

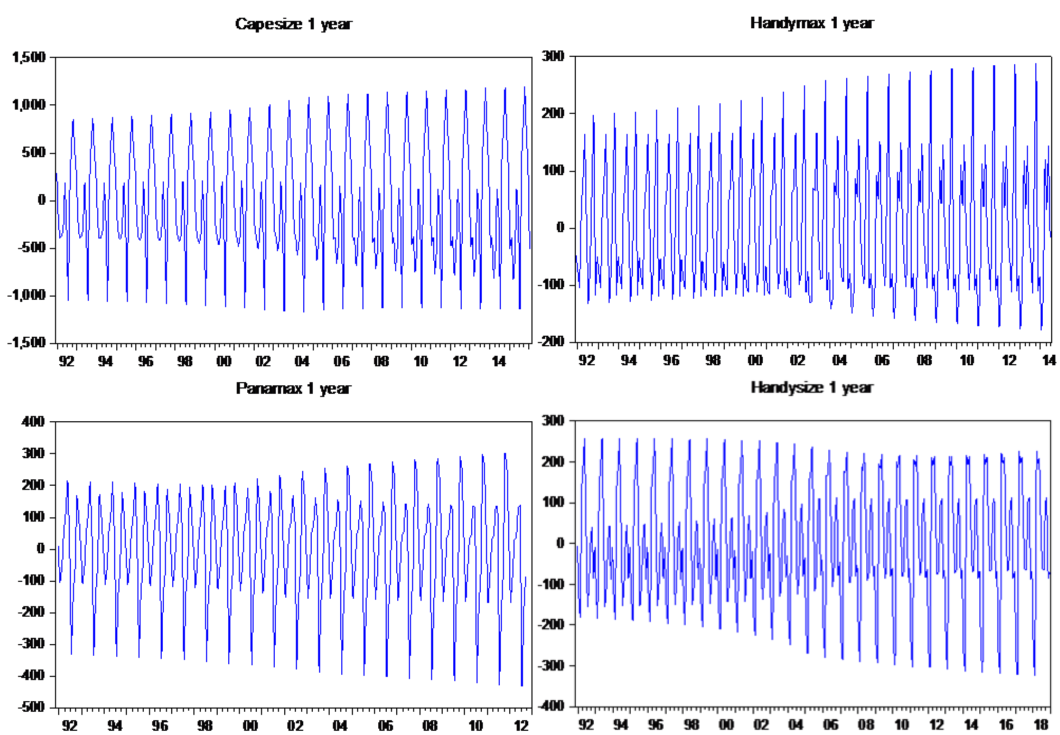
Charter length	Ship size	N	Mean ($/Day)	S.D.	Unit root (p-value)*	Observation period
6-Month time-charter rate	Capesize	289	26,756	27,981	0.198	1992.01–2016.01
	Panamax	250	15,359	13,397	0.262	1991.12–2012.09
	Handymax	271	14,922	11,482	0.333	1991.12–2014.06
	Handysize	328	10,909	7,533	0.276	1991.12–2019.03
One-year time-charter rate	Capesize	290	25,231	25,185	0.245	1991.12–2016.01
	Panamax	250	14,161	12,410	0.275	1991.12–2012.09
	Handymax	271	14,037	10,297	0.360	1991.12–2014.06
	Handysize	325	10,609	6,755	0.351	1991.12–2018.12
Three-year time-charter rate	Capesize	290	21,444	17,118	0.293	1991.12–2016.01
	Panamax	250	11,213	7,318	0.241	1991.12–2012.09
	Handymax	271	12,184	6,266	0.426	1991.12–2014.06
	Handysize	325	9,899	4,307	0.344	1991.12–2018.12
Trip charter rate	Panamax	315	15,933	14,882	0.159	1993.01–2019.03
	Handymax	271	14,487	10,851	0.310	1991.12–2014.06

Note: * The null hypothesis is that the variable contains a unit root.

(A). Seasonal components for 6 month time charter rate



(B). Seasonal components for one year time charter rate



(C). Seasonal components for three year time charter rate

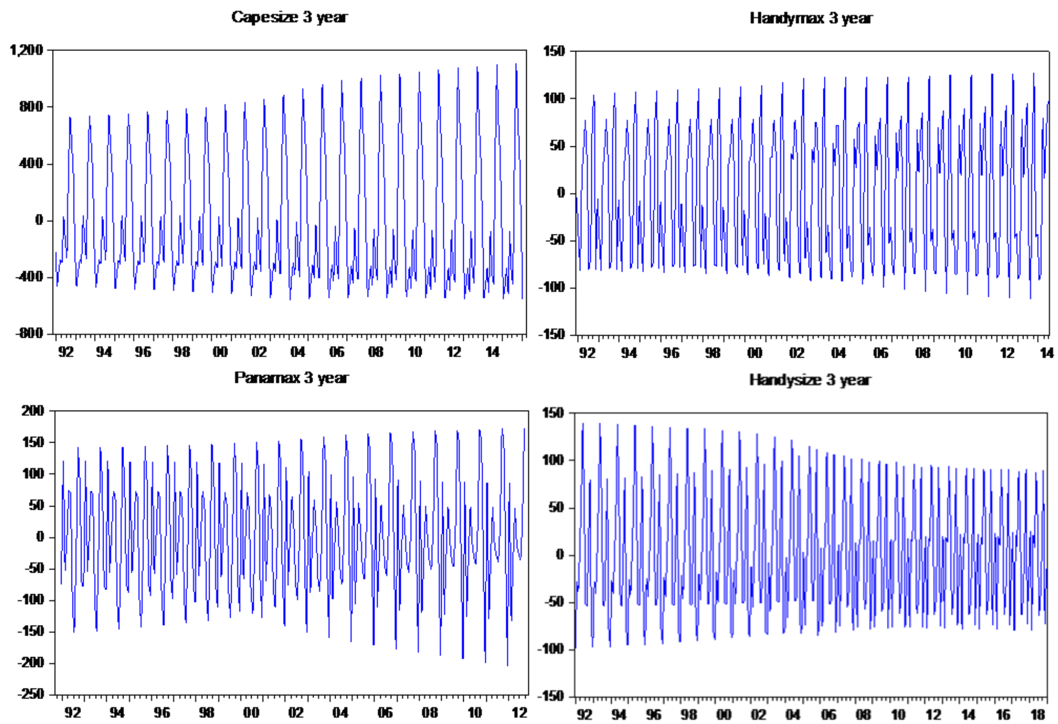


Figure 5-1. Seasonal components of time charter rate with different charter periods for dry bulk carriers

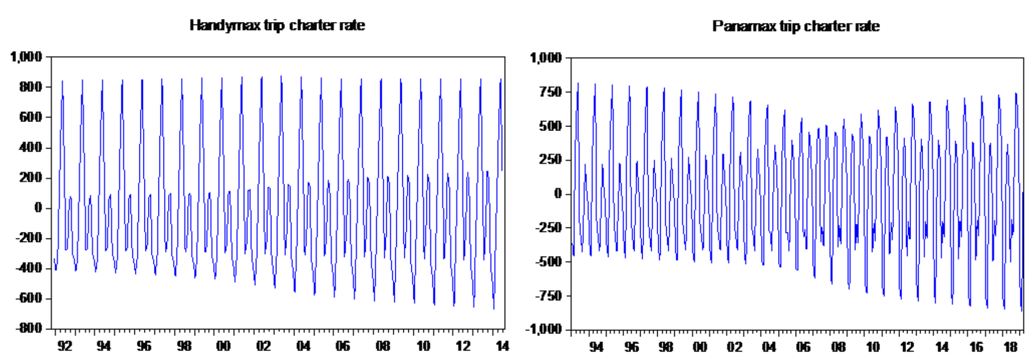


Figure 5-2. Seasonal components of trip charter rate for dry bulk carriers

5.4 Seasonality Patterns in Dry Bulk Freight Rate

Firstly, seasonality analysis is conducted on the whole time series data without taking into consideration the China effect. The results can provide a direct comparison with previous seasonality studies.

The seasonal unit root test results are presented in Table 5-2. Different cycles (0, 6, 3, 5, 1, 4, 2) means that seasonal unit roots exist at different frequencies (0, $\pm\pi$, $\pm\frac{1}{2}\pi$, $\pm\frac{5}{6}\pi$, $\pm\frac{1}{6}\pi$, $\pm\frac{2}{3}\pi$, $\pm\frac{1}{3}\pi$). It is observed that stochastic seasonal unit roots for all sized ships with different time-charter lengths are rejected, which means that to evaluate the seasonality of time-charter rates for bulk carriers, the deterministic seasonality model (Equation 5-1) is appropriate for investigating seasonality.

The results of the deterministic seasonality model are presented in Table 5-3. Compared with the previous results of Kavussanos and Alizadeh (2001) which were based on data from 1980 to 1996, the expansion of the data set in the present study from 1991 to 2016 shows a weaker seasonality effect for time-charter and trip-charter rate. In particular, the seasonality effects in June and July for all sizes of ships no longer exist. Only one factor (March for Panamax 3y TC rate, Panamax and Handymax trip-charter rate) is statistically significant. In addition, the adjusted R-squared statistics are all very low and negative, which implies that the deterministic model is hardly able to explain the information in the data.

Table 5-2. Seasonal unit root test for time-charter rates

Charter length	Ship Size	zero frequency	2 months per cycle	2.4 months per cycle	3 months per cycle	4 months per cycle	6 months per cycle	12 months per cycle
6-Month	Capesize	**–2.47**	–8.62	31.83	23.42	43.54	31.28	18.38
		(0.34)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	**–3.12**	–5.31	18.17	15.62	31.03	27.57	20.03
		(0.09)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handymax	**–2.41**	–4.92	28.76	16.55	39.48	27.25	24.49
		(0.37)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handysize	**–2.81**	–7.23	37.18	22.52	24.70	41.64	33.14
		(0.17)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
One year	Capesize	**−2.57**	−8.62	36.27	17.49	47.44	35.05	19.79
		(0.28)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	**−3.17**	−4.55	30.10	16.87	29.53	26.24	21.26
		(0.09)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handymax	**−2.72**	−3.40	33.48	13.83	47.47	31.21	26.17
		(0.23)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handysize	**−2.12**	−4.32	30.15	28.40	36.88	28.65	22.42
		(0.55)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Three year	Capesize	**−2.60**	−6.97	26.89	28.10	23.96	28.06	24.94
		(0.27)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	−3.60	−3.61	41.88	20.83	30.33	30.93	26.32
		(0.03)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handymax	**−2.52**	−5.44	25.04	19.39	42.35	29.89	25.38
		(0.31)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handysize	**−2.82**	−5.62	29.38	24.43	36.63	35.16	28.08
		(0.20)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Trip charter rate	Panamax	**–1.81**	**–2.36**	17.68	15.22	32.17	30.31	15.96
		(0.67)	**(0.14)**	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handymax	**–2.41**	–4.21	23.89	14.76	37.06	31.19	31.43
		(0.35)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)

Notes: (1) The null hypothesis is that there is a corresponding seasonal unit root. (2) The p-values in parentheses were obtained through Monte Carlo simulations.

Table 5-3. Deterministic seasonality test results for time-charter rates

Charter length	Ship Size	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Adj-R^2	R^2
6-Month	Capesize	–2451	978	261	271	1196	–1341	247	1099	506	–189	141	–720	–0.0206	0.0185
	Panamax	–622	524	1138	–614	100	–681	70	355	190	–335	103	–225	–0.0253	0.0202
	Handymax	–299	364	1054	–234	260	–668	–15	176	332	–331	–455	–182	–0.0127	0.0287
	Handysize	–385	–109	568	269	129	–302	–130	–93	317	–215	–268	224	–0.0050	0.0289
One year	Capesize	−1975	1434	−180	253	916	−952	498	768	72	−449	295	−680	−0.0196	0.0193
	Panamax	−171	458	763	−667	−266	−339	−123	295	671	−558	177	−245	−0.0270	0.0185
	Handymax	−154	330	707	−313	24	−396	185	231	315	−548	−355	−30	−0.0181	0.0236
	Handysize	−190	38	526	70	35	−156	−66	−32	91	−179	−188	55	−0.0159	0.0187
Three year	Capesize	−664	1316	66	334	−113	−465	1210	381	−505	−1470	81	−175	−0.0067	0.0317
	Panamax	−58	146	**558** **(0.09)**	−348	64	369	−29	156	42	−319	−69	−517	−0.0252	0.0203
	Handymax	−33	174	250	−92	88	−179	189	193	122	−441	−288	17	−0.0170	0.0246
	Handysize	−13	0	129	−2	54	0	111	23	45	−264	−155	70	−0.0207	0.0140
Trip	Panamax	–1440	–245	**2109** **(0.02)**	–529	379	–1156	381	–692	695	849	80	–432	0.0220	0.0564
	Handymax	–911	–177	**1674** **(0.03)**	62	898	–928	–531	–376	276	201	–229	41	0.0338	0.0733

Note: Adj-R^2 denotes the adjusted R-squared statistics. R^2 denotes the R-squared statistics.

As shown in Figure 5-1 and Figure 5-2, there seems to be a structural change in seasonality patterns when considering the most recent data extending to 2018. This structural change probably arose from broad-based economic conditions, such as the global financial crisis in 2008, as well as from the volatility of individual commodity prices, such as iron ore. Here, this study attempts to partially explain the change in the pattern of seasonality from the perspective of the effect of China.

5.5 China Effect on Seasonality Evolution

5.5.1 The nature of China effect

Since China entered the WTO in 2003, the seaborne trade volume of dry bulk commodities imported by the nation has increased significantly. As shown in Figure 5-3, the seaborne trade volumes (exports plus imports) of coal and grain have each jumped by a factor of 6 (from 40 to 240 million tonnes), and iron ore has increased by over 18 times. At the same time, Chinese seaborne trade volumes as proportions of world seaborne trade volumes have also risen substantially (Figure 5-4). These increased imports into China would have had a substantial influence on the international supply–demand balance established before 2000. The new equilibrium established in commodity markets may have generated different seasonal behaviours of time-charter rates.

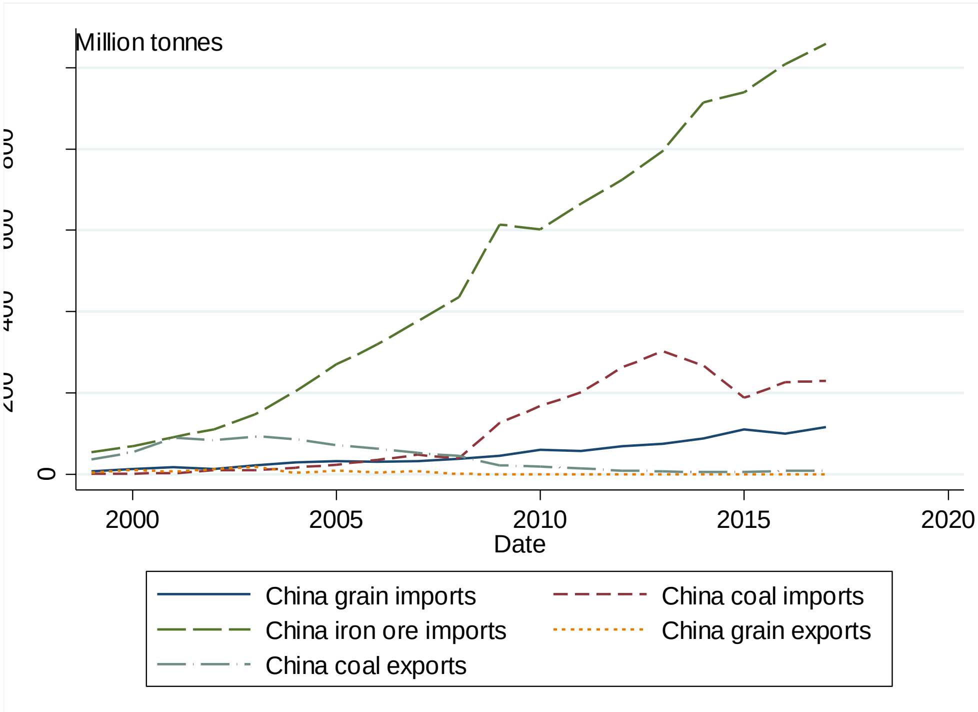


Figure 5-3. China seaborne trade volume of three dry bulk commodities

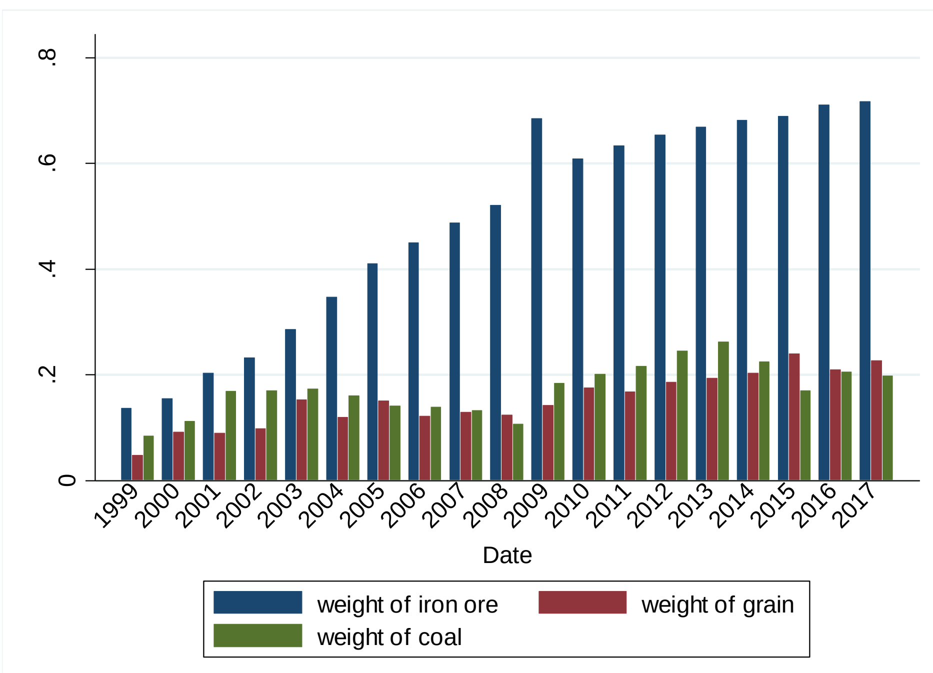


Figure 5-4. China seaborne trade volume as a weight (proportion) of world seaborne trade volume for dry bulk commodities

To measure the effect of China, this research needs to determine the time at which the structural change occurred. According to Figure 5-3 and 5-4, we can observe significant increases in trade volumes of three commodities after 2003. But the weight of coal over world trade volumes begins to decrease after 2003. The imports and exports lines of coal cross in 2008 after which China becomes a big importer of coal. Both 2003 and 2008 seem reasonable. To quantitatively determine at which time point the China trade volume influence world trade balance in the dry bulk market, this research applies the following methodology.

Popp (2007) proposed a modified seasonal unit root test approach to allow for seasonal-level shifts in non-trending data. The advantage of this method is that the seasonal unit root test can be conducted without clearly knowing the break point. Montasser and Gupta (2016) applied this method to investigate the persistence of the industrial production of BRICS, and the results appear to set 2008 as the break point for the China effect. However, this method is appropriate for seasonal mean shifts but not for the structural break, which influences the individual seasonal effects.

Following the methods provided by Perron (2006), this research applied a CUSUM (Cumulative SUM Control Chart) test (Brown et al. 1975) to detect structural change in the time-series data. Specifically, this research applied the CUSUM test to detect a structural break in the time-series data of China's seaborne trade, allowing different seasonal effects to be compared before and after the point of structural change. The same method was also adopted by Lu and Li (2009) to identify the influence of China on the global commodity market.

To conduct the CUSUM test, the variables must first be specified. The aim is to identify the time point at which the demand for freight rate changed. The demand for freight rate is directly related to the seaborne trade volume of major dry bulk commodities. Therefore, the regression is confirmed as a basic ordinary least squares regression of the world seaborne trade volumes of three major dry bulk commodities (iron ore, coal, and grain) on the corresponding China trade volumes. The results of the CUSUM test of recursive residuals of these three seaborne trade commodities are plotted in Figures 5-5, 5-6, and 5-7.

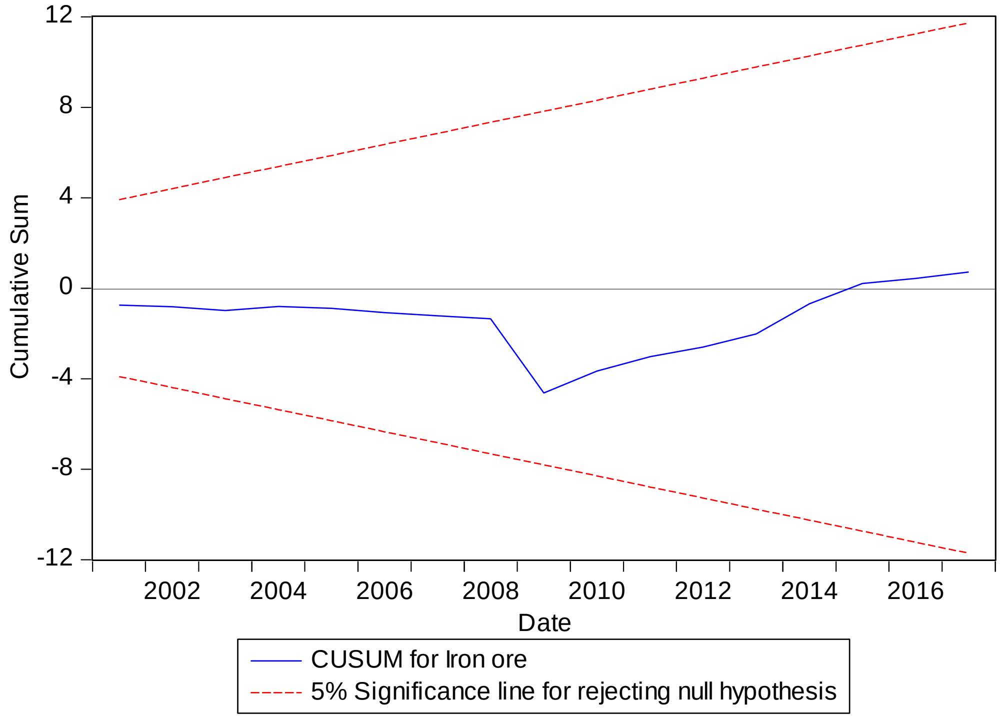


Figure 5-5. CUSUM test for iron ore

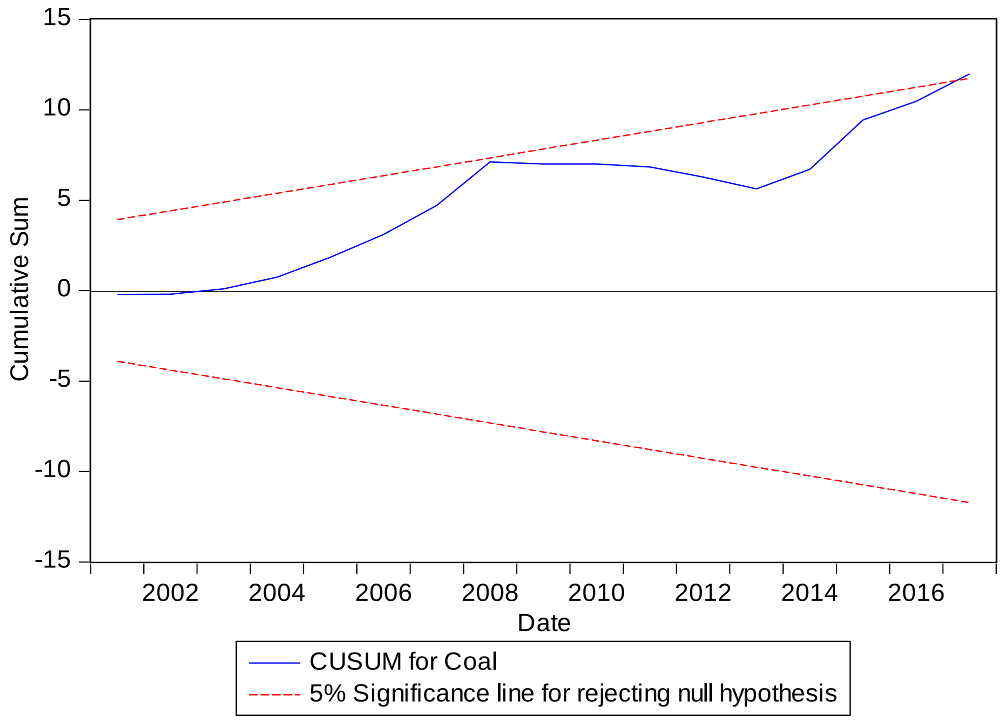


Figure 5-6. CUSUM test for coal

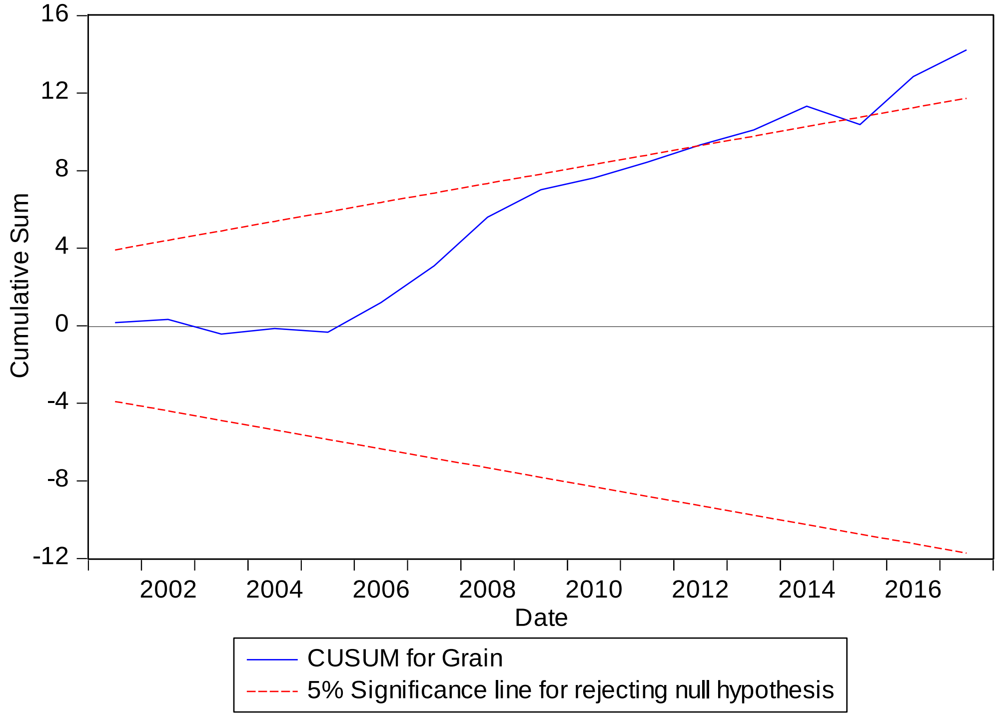


Figure 5-7. CUSUM test for grain

For the three CUSUM graphs (Figures 5-5, 5-6, and 5-7), the overall trend of the CUSUM line does not cross the 5% boundary lines except for grain, suggesting that the import and export of commodities into China has not caused fundamentally different structural changes in the global commodity market. However, significant structural changes are indicated in Figures 5-5, 5-6, and 5-7. In Figure 5-5, a significant deflection in the iron ore CUSUM line is shown at 2009, suggesting a possible structural change. For coal (Figure 5-6), a turning point is located at 2008. Although the CUSUM line for grain is more complex (Figure 5-7), this research selected 2008 as the break point when the CUSUM line begins to deviate from its normal trend. These three break points were examined using the Chow test (Chow 1960), which is used in time-series analysis to test for the presence of a priori structural break within a period. The results of the Chow tests for the three commodities of interest are reported in Table 5-4.

Table 5-4. Chow test of the break point for three commodities

Commodity	Break point	F-statistic	Prob. F
Iron ore	2009	5.23	0.019
Coal	2008	3.86	0.045
Grain	2008	4.01	0.040

Note: The null hypothesis is that there is no structural break at the specified break point.

For the three dry bulk commodities of interest, the demand from China appears to have restructured the equilibrium pattern within the period 2008–2009. Also considering the financial crisis starting in 2008, after which Chinese development more strongly influenced Asia and the world economy (Overholt 2010), this research chooses January 2008 as the point of structural change.

5.5.2 China effect on seasonality evolution

The whole time series data is thus divided into two sections. One section includes the freight rate data from 1991 to 2008 and the other section includes the data from 2008 to 2016. This research assumes the China effect begins to become obvious in the second data section. Seasonality analysis is conducted separately on two data sections.

First, a stochastic seasonality test (Equation 5-2) was applied to investigate the time-charter and trip-charter rates. The results are listed in Table 5-5. For 6 month TC rate before 2008, stochastic seasonal unit roots begin to appear at $\pm\pi$ frequency for Panamax. But after 2008, stochastic seasonality is at all frequencies for Panamax. Similar change is observed for Panamax in 1y and 3y TC rates. For trip-charter rate, the stochastic seasonal unit root becomes more often after 2008. Compared with the results of Kavussanos and Alizadeh (2001), a major change is that stochastic seasonality is observed in around half of the data subsets, in particular for the time period after 2008. Expanding the data from 1996 to 2018 appears to change the pattern of seasonality of time-charter rate identified in Kavussanos and Alizadeh (2001).

Given that deterministic seasonality is rejected for some data subsets, the deterministic seasonality model (Equation 5-2) is no longer suitable for these subsets. However, to allow a more straightforward comparison, this research conducted the deterministic seasonality test on all data subsets, the results of which are reported in Table 5-6. In terms of deterministic seasonality, we find that before 2008, the deterministic seasonality pattern is consistent with results of previous studies (Kavussanos and Alizadeh, 2001), especially, a decline in June for Capesize and Handysize 6m TC rate; an increase in March for Handymax trip-charter rate. For other ship sizes, there is a common pattern of increase in October. The overall trend is that before 2008, the freight rate tends to increase in March, reduces in June and July, and increases in October. However, after 2008, only one seasonal effect (i.e. October) remained and the seasonal effect of October becomes opposite (from an increase to a decrease). This dramatic change could be potentially caused by China's National Day which gives the longest holiday in China. During the first week of October in China, the industrial production is likely to decrease due to the vacation of companies. Another reason is related to the import and export practice of China which shows a significant decline in October (Yin and Shi, 2018).

In terms of the deterministic seasonality patterns across different ship sizes and charter lengths, the seasonal effect of Handymax and Handysize ship charter rates after China effect becomes more significant. The seasonal effect of the trip charter rate, which is found to be most seasonal in previous research, becomes weak after the China effect. While long-time charter rates, such as 3 years and 1 year, their seasonal effects are always significant through the whole time period. The reason is that China effect on freight rate mainly depends on the import of iron ore and coal. These two commodities are produced based on well-planned industrial production and carried by large vessels. There is barely random demand for these two commodities. Therefore, the trip charter rate which provides short term service is less likely to be influenced by the China effect. While long time charter rates show obvious change after the China effect.

In order to investigate whether this dramatic change is caused by China, this study has conducted the seasonality test on the import volume of Iron ore and coal in China. According to UNCTAD Review of Maritime Transport (2019), in 2018 iron ore trading volume takes 46% of the main dry bulks. Among the major importers of iron ore, China, Japan and EU take 71%, 8% and 7% market share, respectively. Meanwhile, the trading volume of coal is 39% of the major dry bulks. Among the major importers of coal, China, Indian and Japan take 19%, 18% and 15%, respectively. The trading volume of grain takes 15% of main dry bulks. Among the exporters of grain, the United States, Brazil and Russian Federation account for 26%, 23% and 11% respectively. From the above, this research expects the seasonality in import volumes of iron ore and coal in China is partially reflected in the freight rate seasonality after 2008. However, due to data limitation, this study cannot find reliable data of grain import from China.

The monthly import volume of iron ore, coking coal and steam coal in China covers the period from May 2004 to March 2019 and is illustrated in Figure 5-8. Coking coal is mainly utilized in steel production while steam coal is mainly in electricity generation. The stochastic seasonality is first tested for three commodities' import volume. The results do not support the existence of stochastic seasonality. Then the deterministic seasonality model is applied to the data. For simplicity, only the deterministic seasonality regression results are shown in Table 5-7.

As we can observe in Table 5-7, import volumes of three commodities decrease statistically significant in both February and October. The mid of February is often the Spring Festival and the first day of October is the national day of China, and both dates provide a long holiday. As a result, industrial production will decrease around these two days and cause a low import volume of raw materials. The decrease in October is consistent with our former results such that the freight rate tends to decrease in October after 2008. Therefore, the change in seasonality pattern of freight rate can be attributed to the involvement of China in dry bulk commodity market.

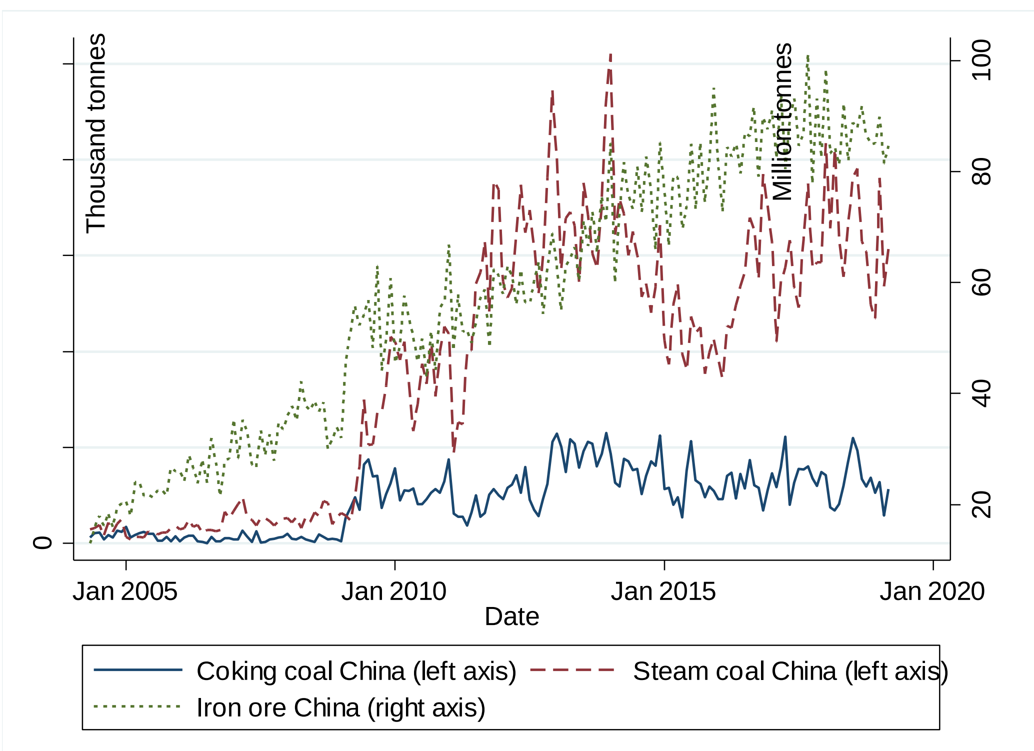


Figure 5-8. Monthly importing volume of iron ore and coal in China

Table 5-5. Seasonal unit root test on time-charter rates

Charter length and data period	Ship size	zero frequency	2 months per cycle	2.4 months per cycle	3 months per cycle	4 months per cycle	6 month per cycle	12 months per cycle
6-Month rates, before 2008	Capesize	**–0.53**	**–2.35**	12.96	10.85	16.73	4.90	**4.66**
		(0.99)	**(0.14)**	(0.00)	(0.00)	(0.00)	(0.08)	**(0.13)**
	Panamax	**–1.31**	–3.81	14.12	15.91	16.31	11.67	**1.70**
		(0.90)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	**(0.67)**
	Handymax	**–0.44**	–5.01	19.47	14.76	13.17	4.96	7.15
		(1.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.09)	(0.02)
	Handysize	**0.61**	–4.41	15.37	12.06	14.81	14.38	10.90
		(1.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
6-Month rates, after 2008	Capesize	**–2.65**	–2.39	9.01	9.19	8.50	7.73	12.76
		(0.18)	(0.10)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	**–0.62**	**–0.73**	**1.20**	**0.07**	**1.09**	**1.51**	**3.32**
		(0.95)	**(0.78)**	**(0.58)**	**(0.98)**	**(0.63)**	**(0.50)**	**(0.12)**
	Handymax	**–0.22**	**–1.87**	6.32	**2.67**	**3.98**	5.28	4.44
		(0.99)	**(0.25)**	(0.01)	**(0.29)**	**(0.13)**	(0.05)	(0.09)
	Handysize	**–0.98**	–3.16	19.51	8.93	**3.95**	10.42	12.51
		(0.95)	(0.03)	(0.00)	(0.00)	**(0.16)**	(0.00)	(0.00)
One-year rates, before 2008	Capesize	**0.22**	−5.62	15.15	3.01	22.28	14.30	9.94
		(1.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	**–0.81**	–2.93	13.20	17.20	9.46	7.92	**1.99**
		(0.97)	(0.04)	(0.00)	(0.00)	(0.00)	(0.01)	**(0.55)**
	Handymax	**–0.92**	**–2.12**	17.31	12.45	18.00	6.48	**4.71**
		(0.97)	**(0.22)**	(0.00)	(0.00)	(0.00)	(0.02)	**(0.11)**
	Handysize	**–0.04**	**–1.99**	20.26	**3.52**	12.38	12.37	6.76
		(1.00)	**(0.30)**	(0.00)	**(0.25)**	(0.00)	(0.00)	(0.01)

Table 5-5 (Continued)

Charter length and data period	Ship size	zero frequency	2 months per cycle	2.4 months per cycle	3 months per cycle	4 months per cycle	6 month per cycle	12 months per cycle
One-year rates, after 2008	Capesize	**–2.70**	**–2.18**	7.27	6.03	16.78	11.56	10.26
		(0.15)	**(0.16)**	(0.00)	(0.02)	(0.00)	(0.00)	(0.00)
	Panamax	**–0.64**	**–0.51**	**0.53**	**0.01**	**1.61**	**2.02**	**1.12**
		(0.94)	**(0.86)**	**(0.81)**	**(0.99)**	**(0.44)**	**(0.36)**	**(0.64)**
	Handymax	**–2.26**	**–2.04**	21.64	15.20	4.92	20.46	19.74
		(0.31)	**(0.19)**	(0.00)	(0.00)	(0.07)	(0.00)	(0.00)
	Handysize	**–0.87**	–4.23	10.05	17.00	4.89	13.19	18.33
		(0.96)	(0.01)	(0.00)	(0.00)	(0.08)	(0.00)	(0.00)
Three-year rates, before 2008	Capesize	**1.28**	–4.74	8.44	16.67	18.85	19.97	10.60
		(1.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Panamax	**–0.99**	**–0.25**	28.60	17.48	8.41	8.50	**1.09**
		(0.94)	**(0.95)**	(0.00)	(0.00)	(0.01)	(0.01)	**(0.78)**
	Handymax	**0.08**	–3.39	11.95	7.36	15.38	6.41	8.13
		(1.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.03)	(0.00)
	Handysize	**0.28**	–2.92	25.82	18.79	23.96	14.84	6.44
		(1.00)	(0.04)	(0.00)	(0.00)	(0.00)	(0.00)	(0.03)
Three-year rates, after 2008	Capesize	**–1.70**	–2.67	11.13	7.78	4.90	4.94	11.80
		(0.68)	(0.07)	(0.00)	(0.00)	(0.08)	(0.06)	(0.00)
	Panamax	**–1.95**	**–0.79**	**0.50**	**0.07**	**0.88**	**0.05**	**3.38**
		(0.36)	**(0.71)**	**(0.84)**	**(0.98)**	**(0.71)**	**(0.98)**	**(0.13)**
	Handymax	**–2.51**	–3.89	42.15	75.65	42.15	28.32	19.02
		(0.21)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
	Handysize	**–0.49**	–4.72	17.16	10.21	**4.26**	14.01	16.74
		(0.98)	(0.01)	(0.00)	(0.00)	**(0.16)**	(0.00)	(0.00)
Trip charter rate, before 2008	Panamax	**–1.31**	**–2.47**	18.90	9.44	13.30	13.64	5.42
		(0.88)	**(0.11)**	(0.00)	(0.00)	(0.00)	(0.00)	(0.07)
	Handymax	**–0.96**	–4.67	15.36	7.80	14.66	9.24	10.05
		(0.95)	(0.01)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)

Table 5-5 (Continued)

Charter length and data period	Ship size	zero frequency	2 months per cycle	2.4 months per cycle	3 months per cycle	4 months per cycle	6 month per cycle	12 months per cycle
Trip charter rate, After 2008	Panamax	**–1.75**	–2.50	12.23	**3.00**	16.18	14.03	16.15
		(0.68)	(0.09)	(0.00)	**(0.33)**	(0.00)	(0.00)	(0.00)
	Handymax	**–0.44**	**–1.00**	4.66	**1.66**	**2.92**	6.09	**3.73**
		(0.98)	**(0.70)**	(0.07)	**(0.59)**	**(0.24)**	(0.01)	**(0.14)**

Note: The null hypothesis is that there is a corresponding seasonal unit root (i.e. the time series is not stationary).

Table 5-6. Deterministic seasonality test on time-charter rates

Charter rate	Ship size	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	R^2
6-Month rates, before 2008	Capesize	–1293	–14	–764	–293	–1136	**–3381**	851	1814	1949	**2867**	–325	–275	0.0915
							(0.09)				**(0.09)**			
	Panamax	–96	–62	343	–853	–1074	–1112	448	754	1047	1108	–91	–408	0.0778
	Handymax	–46	123	271	–253	–551	–873	101	418	680	**987**	–422	–431	0.0691
											(0.04)			
	Handysize	–110	–92	93	–13	–430	**–642**	–11	16	472	572	–55	199	0.0752
							(0.04)							
6-Month rates, after 2008	Capesize	–1363	2634	1985	1071	5531	2612	–1287	–658	–2708	–6627	748	–1937	0.0925
	Panamax	586	2281	3564	34	3738	582	–1256	–1038	–2667	**–6474**	510	141	0.2320
											(0.08)			
	Handymax	142	938	2866	–169	2134	–178	–398	–543	–668	**–3917**	–617	409	0.1839
											(0.04)			
	Handysize	–27	–178	1157	608	871	123	–374	–320	23	**–1430**	–648	191	0.1084
											(0.06)			

Table 5-6 (Continued)

Charter rate	Ship size	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	R^2
One-year rates, before 2008	Capesize	–843	316	–958	–229	–460	–3242	784	**1576** **(0.09)**	1337	**2641** **(0.02)**	104	–1027	0.1110
	Panamax	129	175	168	–961	–1062	–900	111	677	**1528** **(0.03)**	598	56	–519	0.0716
	Handymax	88	186	–1	–387	–523	–682	198	426	526	614	–237	–204	0.0559
	Handysize	–119	64	168	–135	–369	–414	–1	79	188	513	41	–12	0.0587
One-year rates, after 2008	Capesize	126	3272	979	820	3272	3230	–470	–1247	–2857	–7025	279	–384	0.1154
	Panamax	845	1305	2607	216	2223	1395	–929	–986	–2131	**–5477** **(0.07)**	370	559	0.2071
	Handymax	308	668	2334	–134	1283	268	75	–366	–322	**–3724** **(0.03)**	–747	358	0.1746
	Handysize	1	–28	1019	342	593	192	–188	–221	–78	**–1213** **(0.08)**	–547	125	0.0921
Three-year rates, before 2008	Capesize	–173	337	–261	–341	–781	–975	423	863	424	418	216	–154	0.0562
	Panamax	12	–157	52	–406	–230	17	2	**340** **(0.05)**	**892** **(0.00)**	**289** **(0.07)**	–116	–695	0.0633
	Handymax	69	–13	14	–180	–161	–390	181	285	342	225	–285	–86	0.0634
	Handysize	23	–99	–16	–72	–79	–145	49	78	168	234	–77	–62	0.0410

Table 5-6 (continued)

Three-year rates, after 2008	Capesize	565	3076	520	1483	1021	355	2582	–785	–2564	–5448	–390	–418	0.1274
	Panamax	735	1085	2148	–192	975	1468	–160	–465	–2708	–2900	–31	44	0.2202
	Handymax	233	614	803	122	670	317	173	–90	–504	**–2254 (0.03)**	–336	254	0.1538
	Handysize	135	126	322	84	230	193	184	–75	–150	**–1005 (0.02)**	–284	245	0.0836
Trip rate, before 2008	Panamax	–355	–337	1040	–917	–1028	–1568	492	–50	**1368 (0.07)**	**2266 (0.01)**	–151	–759	0.1066
	Handymax	–460	–189	**780 (0.08)**	204	–180	–1119	–352	19	652	**1087 (0.03)**	–124	–313	0.1030
Trip rate, after 2008	Panamax	–1398	–222	**3354 (0.06)**	–135	2163	–727	95	–1700	–356	–1218	260	–120	0.1025
	Handymax	–807	–143	3720	–260	3365	–484	–1097	–1518	–819	–2256	–598	892	0.2207

Note: Adj–R^2 denotes the adjusted R–squared statistics. R^2 denotes the R–squared statistics.

Table 5-7. Deterministic seasonality test on Iron ore and coal import volume in China

Commodity	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	R^2
Iron ore	0.27	**-6.48 (0.00)**	**6.20 (0.08)**	-1.59	-0.84	-1.85	3.04	**-2.36 (0.08)**	5.15	**-9.29 (0.00)**	5.85	1.90	0.34
Coking coal	-68	**-642 (0.00)**	170	456	**-583 (0.00)**	559	147	**-302 (0.02)**	**-123 (0.08)**	**-146 (0.07)**	117	419	0.17
Steam coal	-163	**-2722 (0.00)**	1584	-272	31	-963	964	-64	116	**-1151 (0.01)**	1596	1049	0.23

5.6 Chapter Conclusions

This study examined seasonality characteristics in dry bulk time–charter rates using the most recent data currently available (i.e. to 2018). The data were divided into two periods after accounting for the effect of China on the seasonal demand structure of dry bulk commodities, with the break point being set at January 2008 using the CUSUM tests. The characteristics of seasonality were then investigated and compared before and after the break point.

Further to previous work on time–charter rate seasonality up to 1996, the deterministic seasonality still exists when the data is extended through to 2018. However, in the new time period 1991 to 2018, the deterministic seasonality model is rarely significant, and can hardly capture information of seasonality in the whole time series data. After separating the whole time series data into two periods before and after the China effect, stochastic seasonality in time–charter and trip-charter rate is identified in both periods with different ship sizes and charter lengths. Stochastic seasonality behaviour becomes more often after the China effect. In terms of deterministic seasonality, the China effect does change the seasonal effect of October dramatically, which can be potentially attributed to China's National Day and import export practice.

This result suggests that dry bulk charters and operators who are engaged in iron ore and coal trading, could pay more attention to the seasonal production patterns in China. Shippers could adjust their capacity more wisely using the seasonal movement of freight rate which is influenced by China import volume of major dry bulk commodities.

Chapter 6. Conclusions and Future Research Agenda

6.1 Conclusions

This thesis aims at investigating the shipping market economics. This research field has not been rigorously defined in maritime economics but has its own characteristics which separates it from other research fields. The reasons for focusing on this field are two folds. First, shipping market economics is the basic and fundamental subject for investigating maritime economics. Second, the data applied in shipping market economics has expanded from macro-level to micro-level, which might potentially influence the research topics in that field.

The thesis first conducts a comprehensive review on the research trend of overall shipping market economics. Then based on results from the first study, two independent topics are further investigated. One is the seller buyer domicile effect on second-hand ship price. The other is the China effect on seasonality patterns of dry bulk freight rate.

The first study conducts a bibliometrics analysis of author collaboration, evolution of research topics and methods of 179 papers from 38 scientific journals over the period 1973-2018. The overall trend of shipping market economics is going from technique-driven to idea-driven. New concepts and ideas which are more likely from micro-level and individual behavior perspectives are introduced into shipping market research. At the same time, the availability of micro-level data facilitates the modeling of those new concepts and ideas. The future research directions have thus been suggested: Combining some underdeveloped topics with micro-level or individual behavioral factors.

The second study explores the domicile effect of seller and buyer on the second-hand ship price. In this study, the domicile effects of seller and buyer are confirmed to influence the transaction price. The matching effect between different pairs of sellers and buyers also have different impact on the transaction price. The culture traits and domicile economic conditions related to the sellers and buyers are deciding factors under the domicile effect. The domicile characteristics of sellers and buyers at the micro level are of similar importance to some ship specific factors. The results determine the effect of micro-level factors in explaining macro-level behaviors. This study provides quantitative evidences that the domicile of one's transactional counterpart affects the ultimate transaction price of a vessel. The results put emphasis on the counterpart domicile selection during the negotiation stage.

The third study revisits the freight rate seasonality issue combing the China effect. For freight rate seasonality, the involvement of China in dry bulk market especially after 2008 does change the original seasonality pattern. The new deterministic seasonality effect is consistent with China's import volume of dry bulk commodities. However, the China effect also drives the freight rate seasonality more volatile. Stochastic seasonality becomes more often after the China effect. This result suggests that dry bulk charters and operators who is engaged in iron ore and coal trading, could pay more attention to the seasonal production patterns in China. Shippers could adjust their capacity more wisely using the seasonal movement of freight rate which is influenced by China import volume of major dry bulk commodities.

The results of third study draw people's attention to the demand side of freight rate formation. Though supply and demand theory is the baseline for freight rate research, most of the previous freight rate analysis is focused on analyzing statistical characteristics of freight indexes. An investigation of demand side of freight rate provides a straightforward illustration of how those statistical characteristics are formed.

Overall, the research interests in shipping market economics are gradually switching from macro-level to micro-level. Some micro-level factors and concepts are introduced into shipping market economics. With the help of those innovative attempts, insights are brought into some complex market phenomenon.

6.2 Future Research Agenda

Though in each study, efforts are made to account for potential problems arising from the research design, some limitations are inevitable.

Specifically, in second-hand ship price study, the use of investors' domicile neglects the heterogeneity among different shipping companies within any one country, which may result in a bias in the fixed-effect analysis. However, the available empirical data presently does not allow for a more disaggregated analysis, and the current study leaves this for future research.

In freight rate seasonality study, though the results show that China effect does bring stochastic seasonality, there is no appropriate model to capture those stochastic features. Only deterministic seasonality model is applied to measure the seasonal effect. In future research, some alternative models should be considered, such as SARIMA and factor models.

The future research directions in shipping market economics should be more driven by ideas and innovation. In the past research, extensive efforts have been made on the "index study". The research potential of standardized macro-level data is declining. While more and more micro-level data become available. Micro-level factors, like individual characteristics or behavioural, are often incorporated into market analysis. With the help of those micro-level factors, some highly developed topics like volatility study and tanker market could be revisited.

Furthermore, in current shipping market economics, the freight rate market is an active and promising research field. Though this field receives consistent attention during the whole period. The researches about this market still left much potential. One possible reason could be related to its commodity property. Freight rate cannot be stored nor traded, therefore time factor becomes very important. Though many freight futures derivatives are invented to hedge those risk. Potential future research direction could be investigating influencing factors accounting for why freight rate could be such sensitive to time factors, such as its term structure and risk premium.

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