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Price Dynamic Analysis of Baltic Clean Tanker Index (BCTI)

by

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This MEL journey goes back years ago. I first discovered this program in 2018 when I was still in my undergraduate study. I also found out that the scholarship requires me to have a work experience of minimum 2 years. Since then, it has been in my life plan to study in the Netherlands, particularly in this specific program. I hope that all the time and dedication during the preparation and the study will pay off, to shape me as a better maritime professional.

Abstract

Petroleum is one of the major commodities in shipping transportation. First transported in 1861, the market has grown and shaped the tanker industry. The spot market contract has been the main business model in the shipping industry since the 1970s. Due to its importance, tanker freight rate modeling and forecasting have become major academic research topics for years. Freight rate research predominantly focuses on time series analysis and macroeconomic analysis with crude oil tankers datasets. The effect of individual contracts is often missed in research topics, while this information contains several important microeconomic determinants of tanker freight rates. Moreover, there has been very little academic research that has used the clean tanker segment. Therefore, the aim of this thesis is to investigate the elements from individual spot charter contracts that affect price dynamics. The Baltic Clean Tanker Index (BCTI) is used as the indicator to link market information of the clean tanker segment. Individual spot contracts and the daily BCTI index are obtained from Clarkson's Shipping Intelligence Network (SIN). This research used 9,416 individual spot contracts of handysize clean tankers from January 2020 to June 2024. To estimate the effect on BCTI, this thesis employed panel data methods of fixed effects model and random effects model. The study revealed that there are time elements, geographical elements, cargo elements, and vessel information elements that could be used to conduct the analysis. The analysis further revealed that different time element variables affect the BCTI differently. In addition, the clean tanker market is segmented based on routes with various market indices. Different cargo types are associated with various index levels, with a few particular cargoes linked to higher indices. Lastly, all of the vessel element information positively affects the BCTI.

Keywords: Tanker freight rates, shipping routes, CPP, BCTI, panel data

Table of Contents

Table of Contents

List of Tables

List of Figures

List of Abbreviations

AG – Arabian Gulf

BCTI – Baltic Clean Tanker Index

BDTI – Baltic Dirty Tanker Index

BSEA – Black Sea

CAP – Condition Assessment Program

CPP – Clean Petroleum Product

DWT – Deadweight Tonnage

ECSA – East Coast South America

EM – East Mediterranean

IMO – International Maritime Organization

LR1 – Long Range 1

LR2 – Long Range 2

MARPOL – The International Convention for the Prevention of Pollution from Ships

MR1 – Medium Range 1

MR2 – Medium Range 2

MT – Metric Ton

NM – Nautical Mile

OPEX – Operational Expenditure

RNR – Rate Not Reported

SIN – Shipping Intelligence Network

TBN – To Be Nominated

TCE – Time Charter Equivalent

ULCC – Ultra Large Crude Carrier

UKC – United Kingdom Continent

VIF – Variance Inflation Factor

VLCC – Very Large Crude Carrier

WCSA – West Coast South America

WM – West Mediterranean

WTI – West Texas Intermediate

WS – Word Scale

Chapter 1 Introduction

This chapter will discuss the background of the topic which is a price dynamic analysis in the handysize clean product market and why it is a significant problem that needs to be addressed academically. After discussing the study background and the problem, then we will formulate and discuss the research questions and the sub-questions that will be addressed in this thesis which is the microeconomic determinants in the clean tanker market. Following that, this chapter will briefly explain the research design and the methodology. Concluding chapter one, the thesis structure will be presented as the last section of the chapter.

1.1 Background

Petroleum is one of the main commodities in seaborne trade with dry bulk. After its depressing market in pandemic era due to minimum petroleum consumption, oil commodity seaborne trade had the highest annual growth rates in 2022, compared to another seaborne commodity (UNCTAD, 2023). Moreover, oil commodity is still expected to grow in the future amidst the energy transition policy in recent years as since 2023, a total of 10.8 million DWT of newly built crude oil tankers have been delivered to ship owners (Clarkson, 2024).

The tanker freight market segment has been the main subject of academic research in shipping and freight rate analysis for years. This is unsurprising as the percentage share of global oil tankers fleet in 2023 is at 28.7%, after bulk carriers' fleet as the most type of fleet globally at 42.8% (UNCTAD, 2023). With these sizeable fleet size and a matured market, the tanker segment has been used greatly in maritime industry research, using Very Large Crude Carrier (VLCC) and Ultra Large Crude Carrier (ULCC) tanker size which focusing on the crude oil market segment.

Shipping industry is infamous for its risk and market volatility. Therefore, freight rate and market analysis has been the heart of research topic in the maritime scope. Most tanker freight rate research were macroeconomic wise, as they looked for the correlation between freight rates and crude oil prices. Sun et al (2014) used ensemble empirical mode decomposition model with Baltic Dirty Tanker Index (BDTI) for the freight rate data and West Texas Intermediate (WTI) for the oil price reference. They found a variation in different time scale, with the medium patterns show a positive correlation and a strong negative correlation in the long-term trend. Similar approached conducted by Khan et al (2021), by exploring the correlation of oil price and BDTI with the presence of Global Economic Policy Uncertainty (GEPU) in the wavelet analysis. The study suggests that oil price is a significant contributor to the price changes in the tanker freight rates. With the presence of GEPU in their model, the correlation of the two variables is more evident and shows that global uncertainty is also contributing to the oil price and tanker freight rate. GEPU also reflects uncertainty and need of higher security, which is reflected in the price changes of BDTI.

Model evaluation for freight rate forecasting was also the main research topic in the tanker domain. Christodoulopoulos (2020) used ARIMAX model with the introduction of twelve exogenous variables to improve the forecasting accuracy of the model for predicting various vessel sizes rate in the dirty market. His research suggests the model only performed better with the addition of oil price as exogenous variable in the Panamax dataset. Gjergji (2021) used neural network application of three models to forecast oil tanker freight rates in VLCC and Suezmax size. The models that were used generally outperformed naïve forecasting methods as the baseline model.

Generally, freight rate analysis in the tanker market has always been using exogenous variables and macroeconomics, along with correlation analysis of oil price and tanker freight rate. To the best of author's knowledge, only few studies have conducted micro determinant analysis in the freight rate analysis, which uses information of fixture data which is generated on a daily basis in the market from chartering practice. Alizadeh and Talley (2011) used fixture data information of three vessel sizes in the tanker dirty market from January 2006 to March 2009 to analyze the importance of laycan period in shipping contracts. The study found that laycan period is an important determinant and positively related to the freight rate. When tanker shipping costs increase, it typically indicates a scarcity of available tanker vessels. As a result, companies that need to charter tankers become proactive. They enter the tanker charter market earlier than usual, aiming to secure their transportation needs well ahead of time. This strategy helps them avoid potential difficulties in finding suitable vessels later due to the anticipated shortage.

This different microeconomic approach was also able to unfold hidden and non-evident market dynamics in the shipping industry. While almost every tanker freight rate analysis has always been using information and data from the tanker dirty market, it is crucial to note only few were using data from the clean tanker segment. The lack of research in the clean product markets is caused by the diversity of the type of cargo carried at sea and the trading routes themselves. This gap presents an opportunity that could provide insights into tanker clean market dynamics with similar approach.

1.2 Research Objective and Research Question

As discussed in section 1.1, we came up with the state that most freight rate analysis have been in the horizon of macroeconomic determinant. Moreover, the research in tanker market have been limited to only in the dirty market segment. This research aims to fill the gap of the lack of microeconomic study in the freight rate analysis by examining individual spot contract in the handysize market, with more attention in the clean tanker segment. Therefore, we conclude to address the research question and sub-questions as follow:

Research Question:

"What elements of individual tanker spot fixture information affect the Baltic Clean Tanker Index (BCTI) in the handysize tanker market?"

Sub-questions:

1. How do time elements in the fixture's information affect price dynamics?
2. How do geographical elements in the fixture's information affecting price dynamics?
3. How does specific cargo type affect price dynamics?
4. How does vessel information affect price dynamics?

Charter fixing concluded on a daily basis and in the contract itself contains several commercial information such as the freight rate, laycan period, port location, and several other information. The study by Alizadeh and Talley (2011) showed that one of the variables is an important determinant in the freight rate and in this research and we will explore other variables from the available information. The variables will be discussed extensively in a separate section in chapter three.

1.3 Research Design and Methodology

This thesis will focus on data exploration of fixtures' compilation and transformation, to be able to perform a price dynamic analysis. Due to the series of trends from the dataset, this thesis will employ quantitative analysis using cross-sectional analysis to unfold the dynamics by exploring using compilation of contracts or fixtures in the market. While Alizadeh and Talley (2011) concluded the effect of the duration of laydays to the freight rate, Prochazka et al (2019) presented the behavior of charterer and ship owners in the tanker market by analyzing spatial distribution of the vessel location when the contracts are concluded. With this behavior, we will create variables that are not available in the base fixtures' information to present time elements and geographical elements of the contract's dataset. Moreover, we will also investigate the effect of clean liquid bulk commodities to the price dynamics in the market.

To do the dynamics analysis, we will use BCTI as the dependent variable in our model. We will discuss the BCTI more extensively in section 2.3. BCTI is a series of index over a period of time. The index is available on a daily, weekly, monthly, and yearly basis which comprised of an index that is acquired by a calculation method. A time-series data is a series of chronological sequence of observations on a variables (Montgomery et al., 2011). Based on the definition, then we can argue that our first dataset which is the BCTI is a time-series data as it is comprised of an observation of index, that comes in a chronological order over a period of time.

Our second dataset is the individual spot contract. Unlike the BCTI dataset, it is comprised of a several observations over a period of time. The observation in this dataset is a series of information of a specific vessel and her specific commercial contract information on a specific point of time (Wooldridge, 2024). Therefore, we can argue that in a single observation of the dataset, it is called as a cross-sectional data (Kesmodel, 2018). With the combination of the two datasets, they are called a panel data. Hence, we will use the appropriate model that suits with the profile of panel data's structure. These models will be discussed in section 3.3.

Handysize vessel is generally known to carry clean products and utilized in regional trade with flexibility on port restrictions (Stopford, 2008). Clean products have variety of cargo types and qualities that vessels will have to comply on the cleanliness and suitability of their tanks to carry certain grade of cargo. Therefore, it is interesting to explore the influence on the price dynamics based on the type of cargo. Once all variables are gathered, we will then do the cross-sectional analysis by examining individual handysize spot contracts.

1.4 Thesis Structure

The thesis will be comprised of six chapters with chapter one as the introduction of the thesis. Next, we will discuss the research context. In this chapter, we will discuss the tanker fleet in general with trade trend of oil transportation. Moreover, we will also put focus specifically on clean liquid trade market. Following that, we will also introduce chartering practice in the industry in the research context. As we will use data from individual spot fixture information, it is important to also discuss chartering practice which generates the data information of fixtures. In this chapter, chartering and fixture fixing will be discussed extensively. More importantly, we will introduce the BCTI which is the market index and information of ocean going and maritime transportation.

Next, chapter three is the literature review and methodology. In the literature review, we will discuss the previous research in the same field and context which is oil product transportation and market analysis which uses the same approach. In this research, we will emphasize the use of individual spot fixtures information; thus, we will explore and discuss previous research that use similar dataset or approach. Moreover, we will discuss the type and attribute of our dataset before we conclude the methodology that will be used in this thesis. To summarize, the data profile in our research is a panel data; hence, we will use appropriate model to analyze panel data. In this thesis, we will use fixed effect and random effect models; thus, we will discuss the two models and highlight the main different of the two regression models.

In chapter four, we will discuss extensively the data that is used in this thesis. We will present the raw data that was first acquired and how we processed the data to conduct the analysis. Also in this chapter, we will discuss the exploratory data analysis that we will use in this thesis to be able to conduct the market analysis, along with the model explanation as the theory that we used to conclude the variables. Lastly, we will present the final dataset after the data modification and manipulation to be appropriate for this thesis.

Then, we will discuss the result and analysis in chapter five. We will see the statistical analysis and the model comparison, which model could explain and answer the research question better. Lastly, we will conclude the thesis in chapter six, and answer all the main research question and the sub-questions.

Chapter 2 Research Context

This research primarily discusses the context of the research that is reflected in the industry. In chapter one, we have described petroleum transportation development briefly and few developments of freight rate analysis. Given the context of petroleum and the tanker transportation, we will introduce this chapter as the introduction of the petroleum and tanker industry, along with the chartering practice as a research context.

2.1 Tanker and Oil Transportation

The very first oil transportation dated back in 1861 from Pennsylvania to London, transporting crude oil in barrels (Stopford, 2008). Before 1970s, most tanker businesses were operating in time charter business and when the oil trade were declining, the fleet supply side became excessive and the market operation then mostly operating in a spot business.

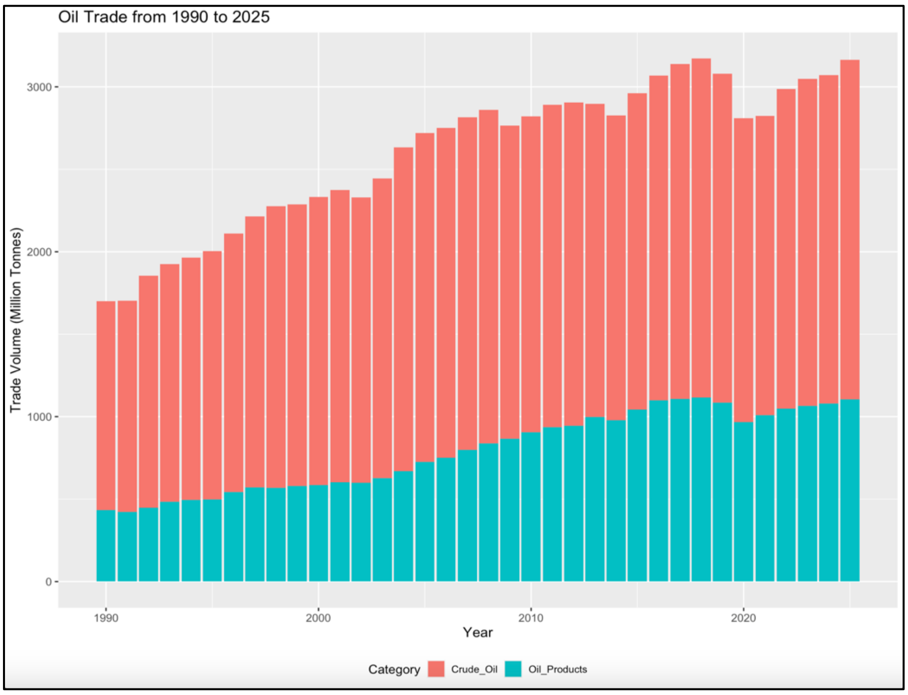

Figure 1. Stacked Bar Chart of Oil Trade Quantity in Million Tonnes (Source: Drawn by author based on Clarkson's SIN)

Figure 1 above depicts a constant growth of oil trade in the form of both crude oil and oil products in various forms. Hence, the tanker fleet supply has been growing as well over the years and the tanker market has been segmented based on the size, cargo, and the routes (Gjergji, 2021). In general, the broad market of tanker segment are the crude oil market and the clean products market. The crude oil market existed to transport crude oil products from an oil producing region to another region with big refineries to process the crude oil. In this crude oil segment, commonly they are transported with vessel at the size of VLCC and Suezmax with a long-haul distance; however, Aframax is employed to carry crude oil in a shorter distance and occasionally transporting clean products as well (A. Alizadeh and Nomikos, 2009). While in oil products trade, they are transported in a smaller vessel size. Below table shows the major crude oil trade and flow which transported in a smaller vessel as well by Suezmax or Panamax.

Table 1. Major Crude Oil Trades and Flows

Crude Oil Trades and Flows
Middle East to Far East, NW Europe, USA, Indian sub Continent, South Africa, Brazil, Red Sea, Mediterranean & Australasia
Red Sea to Far East, USA, NW Europe & Mediterranean
West Africa to Far East, NW Europe, Mediterranean, Indian sub Continent, USA & South America
North Africa to Mediterranean, NW Europe, USA & Far East
North Sea to USA & Far East
Baltic Sea to UKContinent, Mediterranean, USA & Far East
Black Sea to UKContinent, Mediterranean, USA & Far East
ECMexico to USA, Europe & South America
Caribbean to USA, Europe, South America, Indian sub Continent & Far East
South America to USA, Europe & Far East
Indonesia/Malaysia to Far East & Australasia

Source: The Baltic Exchange, 2014

While crude oil is commonly transported in a larger size, oil products are transported in a relatively smaller size which rarely exceed 60,000 Metric Ton (MT) (A. Alizadeh and Nomikos, 2009). At this quantity, the oil product markets are generally transported at the size of a Panamax or Handysize. The common clean petroleum product (CPP) in the market is ultra-low sulphur diesel oil, jetoil, gasoil, gasoline, and etc (Plomaritou & Papadopoulos, 2017). In the Panamax size, they are also often called as Long Range 1 (LR1) and Long Range 2 (LR2) as they are transporting clean products in a longer distance which often passing the Suez Canal. The LR1 size able to load typically between 55,000 – 65,000 MT while LR2 typically with a larger quantity at 75,000 – 90,000 MT. The handysize is also called with a different name with quantity segmentation as well as Medium Range 1 (MR1) and Medium Range 2 (MR2). The typical MR1 size is at 25,000 – 40,000 MT while MR2 able to transport at 40,000 – 55,000 MT. According to The Baltic Exchange (2014), below table is the major CPP trade flow.

Table 2. CPP Trade Flows

Major CPP Trades and Flows
Middle East to USA, Mediterranean, Europe & Far East
NW Europe to USA, Mediterranean, West Africa & Far East
Mediterranean to NW Europe, USA & Far East

USGulf to South America & Europe
Caribbean to USA & Europe
Indian sub Continent to USA, Mediterranean, Europe & Far East
NE Asia to USWC & WC South America
Singapore to Worldwide destinations
Inter-regional trade within Europe/Mediterranean
Inter-regional trade within Middle East & Indian sub Continent
Inter-regional trade within SE Asia & Far East

Source: The Baltic Exchange, 2014

Bai (2019) found the trading patterns for the Panamax size in CPP market which are LR1 and LR2 by examining AIS data. For LR1, the main trading route for this vessel size is the Middle East to Asia with the addition of West Africa to Europe as a significant market route as well. Likewise, LR2 main trading route is also between the Middle East to Asia as the Middle East region is the largest exporter of CPP products with Asia as the biggest importer region. Europe with their abundant stock of naphtha, became an important trading route as well for LR2 market with Asia still as the biggest importer of Europe's naphtha. She also found a conclusion that due to its flexibility by its size, there are no significant trading route pattern for the MR size.

As discussed, the shipping industry market is characterized by the vessel sizes. Different vessel sizes represent different market segmentation in the cargo trade flow and shipping routes. Below table shows the summary of different vessel segment and its DWT capacity in the tanker segment.

Table 3. Tanker of Different Sizes

Segment	**DWT**
VLCC	>200,000
Suezmax	120,000 – 199,999
Aframax	80,000 – 120,000
Panamax	60,000 – 80,000
Handysize	10,000 – 60,000
Small Tankers	<10,000

Source: Stopford, 2008

2.2 Chartering

Chartering is referred as the term of vessel employment which is negotiated between ship owner and charterer. Ship owner refers to the owner of the vessel which in a contract, they represent the interest of their vessel while charterer is the party that hire the vessel for a specific voyage or for a certain period of time. The negotiation is written in a commercial contract called charter party and as a compensation for the transportation, the charterer will pay a negotiated freight rate to the ship owner as part of the commercial negotiation (Plomaritou and Papadopoulos, 2017).

Chartering comes in few different forms. Typically, the basic forms are divided based on the functional view of the vessel. The first form is a voyage charter. This type of charter concentrates on a specific trip to carry a cargo between several ports. As a result, the charterer of this charter will pay a predetermined freight rate for a specific voyage. In this form, the charterer does not have any influence on the operation, only for a specific trip of voyage that is related to the cargo which has been agreed. Next form is time charter. Instead of a specific trip, this charter form focuses on a certain period of time. In this form, the commercial operation is arranged by the charterer. During the time charter employment, the freight is called as a hire and calculated per day. The last common form of charter is a bareboat charter for a certain period of time as well. The differences with the time charter are instead of only commercial operation, the vessel is fully controlled by the charterer. This means that all commercial operation and the technical operation are fully arranged by the charterer. Every cost except for the capital cost is also paid by the charterer. Below table summarize the distinction and responsibility of a charter based on the cost division. The C in the table stands for charterer, while O represents vessel owner.

Table 4. Cost Division in a Charter Contract

	Bareboat Charter	**Time Charter**	**Voyage Charter**
Port Charges	C	C	O
Bunkers	C	C	O
Maintenance	CO	O	O
Insurance	CO	O	O
Capital Cost	O	O	O

Source: Plomaritou & Papadopoulos, 2017 p. 242

In principle, chartering process is a flow of exchanging information. As a starter, the chartering process started off with an indication phase which both the ship owner and charterer are willing to start the negotiation. At this state, the principal communication involves information such as type of cargo, quantity of cargo, date of the shipment, and the freight indication that the charterer is willing to pay for this specific cargo (Plomaritou & Papadopoulos, 2017).

The form of charter party is fundamentally a negotiated term, which according to Dobre (2016) the terms are divided into three groups which are conditions, guarantees, and intermediate terms. Conditions are promises made by the ship owner to the charterer that they will fulfill all their obligations in a contract to be able to perform the shipment on the agreed date. If this is not fulfilled, there is a serious consideration that the contract is incomplete and may lead to potential damages. In this term and agreement, guarantees are provided in the terms of minor clauses in which if the guarantees are breached, the contract is not regarded as incomplete; however, might arises compensation claims from either party. Such complexity in a contract gives a provision clause that cannot be seen as either a guarantee or conditions. As such, intermediate terms presented as the line between both terms which is determined by the loss of one party.

Chartering process is a process of negotiation with the exchange of information at a swift rate. Plomaritou and Papadopoulos (2017) described that the chartering process and negotiation is divided into three stages in the following figure.

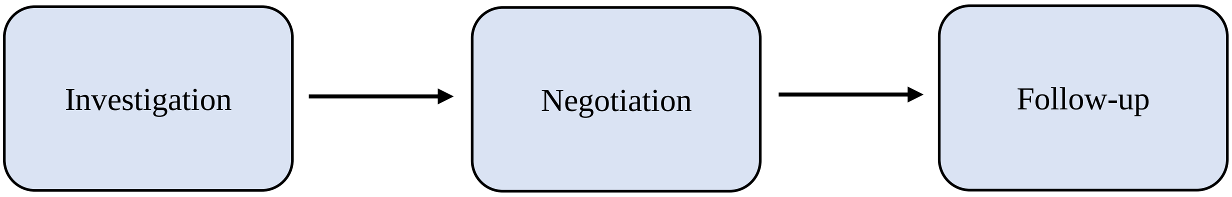

Figure 2. Negotiation Stages (Source: Plomaritou and Papadopoulos, 2017)

In the investigation stage, this is the phase that the charterer first enters the market, either via broker or directly to the ship owner that they have done business with. At this stage, this is called as a cargo order. The cargo order comprised of information of the specific type or charter that the charterer wishes, the type of cargo, and the type of vessel that is required by the charterer. The information is not limited to also of the port rotation, laycan indication, and few restrictions if any. In this early stage, the sale of the cargo might not be concluded yet as the charterer is often trying to get an indication of the freight rate for their cargo's interest. Only when the cargo transaction on their side is firming up, they could decide to move on to the next stage of the chartering negotiation. On the ship owner side, their daily chartering activity is usually done by sending their fleet's position list in the market. This list consists of information such as their available fleet information such as the name, the DWT, and the last three immediate cargoes. Most importantly, they will inform each vessel's geographical position and their prompt availability.

After the investigation stage, the chartering process moves to the negotiation process. After receiving sufficient information of the contract indication by the charterers or brokers, the owner will revert to them with a freight indication. This is acquired by considering the bunker cost for the port rotation, the port costs, canal fee if any, and the fixed cost of the vessel. This base rate from their indication will be the base of the negotiation if the charterer is interested to move forward. At this stage, if the charterer is interested with the freight idea, then the ship owner will return with a firm offer. The negotiation then will start and there could be several counters offers between the two or three parties regarding the base offers for the freight rates, vessel nomination, laycan and laytime duration, the demurrage rate, commissions, and the charter party form which will be the base of the contract terms. If these are concluded, then in the negotiation process, the vessel and the owner will be preliminary concluded as the vessel is now "on subject" by the charterer's end. At this stage, they will discuss in accordance with the charter party form that the charterer wishes to do with.

In the follow up stage, when the fixture is finalized then they will move the vessel as subject lifted which means that the contract is fixed. The charter party will be drawn up according to the terms in the charter party. Traditionally, the charter party will be printed and the owner and charterer (or broker on their behalf) will sign on the charter party. The fixed contract is also often called as clean fixture and the broker will come up with the recap of the main terms and several additional clauses which is called clean recap. The clean recap is often consisting of the following information.

Table 5. Clean Recap's Information Details (Spot Voyage)

Item	Description
C/P Date	The date when the contact is agreed
Charterer	Charterer's full style details
Owner	Owner's full style details
Vessel	Vessel name
Vessel's Itinerary	Vessel itinerary from the previous provision and the expected date at each port
Vessel's Last Three Cargoes	Last three immediate cargoes that the vessel transported prior to performing the current contract
Cargo Details	Cargo description and quantity
Loading Port	The specified loading port
Discharging Port	The specified discharging port

Laycan	The laycan period of the contract
Payment Terms	The freight rate payment terms by the charterer to the ship owner
Laytime	The agreed laytime to be used at both port
C/P Form	The agreed form and type of charter party
Commission	The commission to the charterer (if any) and to the brokers
Special Provision	Additional clauses in the contract (if any)

Source: Author's compilation from multiple sources

2.3 Baltic Freight Index

The Baltic Exchange has been constructing market indices of ocean-going freight rates since 1985 that gives information of the freight market (Kavussanos et al., 2021). The process was done by collecting information of transactional freight rates via shipbrokers and they calculated the average of these freight rates. These calculations are published as an information of freight rate indices which have been the market information for freight rates. The index is reported on a daily basis at 11 o'clock in the evening London time, to represent the market information based on an actual figure that have been collected. The indices are available in the dry bulk segment, tanker segment of both clean and dirty market, gas segment, and the container market.

In the tanker segment, initially they have ten routes for the dirty market and only four for the clean market. The indices are calculated by multiplying the average rate for each route with a weighing factor for each route in the index that was calculated by the so-called panelists in the Baltic Exchange team (Lyridis, 2006). Today, the dirty index is comprised of 16 routes and 19 routes for the clean index. Below table is the list of routes that is available in the BCTI (The Baltic Exchange, 2021).

Table 6. BCTI Routes

Index	Description
TC1	Middle East Gulf to Japan (CPP, UNL, naphtha condensate)
TC2_37	Continent to US Atlantic coast (CPP, UNL)
TC5	Middle East Gulf to Japan (CPP, UNL, naphtha condensate)
TC6	Algeria to European Mediterranean (CPP, UNL)
TC7	Singapore to east coast Australia (CPP)

TC8	Middle East Gulf to UK-Cont. (CPP, UNL)
TC10	South Korea to NoPac west coast (CPP/UNL)
TC11	South Korea to Singapore (CPP)
TC12	Sikka (WCI) to Japan (naphtha)
TC14	US Gulf to Cont. (CPP, UNL, diesel)
TC15	Med / Far East (naphtha)
TC16	Amsterdam to offshore Lome (CPP)
TC17	Middle East Gulf to East Africa
TC18	US Gulf to Brazil
TC19	Amsterdam to Lagos (CPP)
TC20	AG/UK Cont
TC21	US Gulf to Caribbean
TC22	Yeosu/Botany Bay
TC23	ARA to UK-Cont

Source: Baltic Exchange, 2021

Although they have 16 routes in their report, they only used six of these routes in their index calculation. These six routes are the TC1, TC2_37, TC5, TC6, TC16, and TC23. To be able to acquire the daily index that is posted by the Baltic Exchange needs a subscription. However, the Baltic index is available via other subscription, for instance via Clarkson's Shipping Intelligence Network (SIN) database. Below figure depicts the time series graph of yearly BCTI since its first introduction.

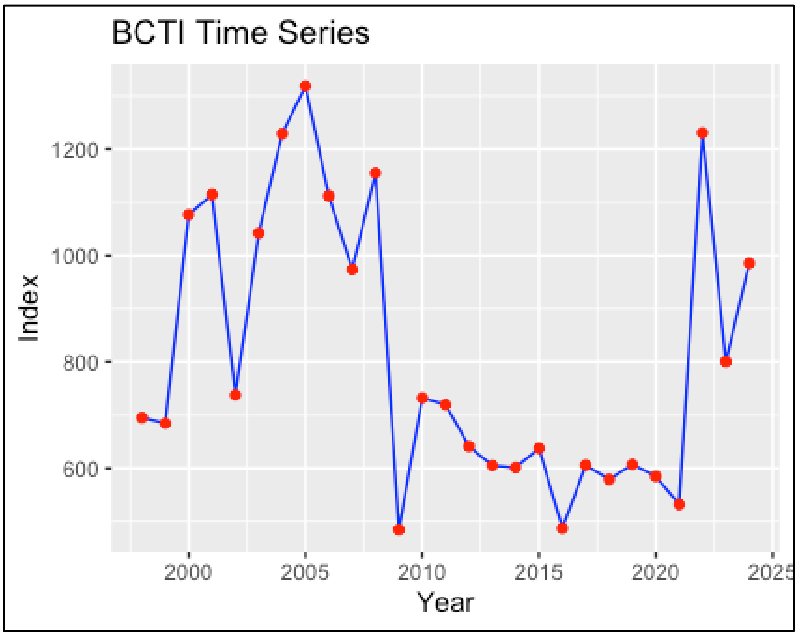

Figure 3. Yearly BCTI Time Series
(Source: Drawn by author based on Clarkson's SIN)

Chapter 3 Literature Review and Methodology

Chapter three is comprised of three parts. In the first section, we will explain our search strategy which discusses the resources and the used keywords. Following that, we will discuss the previous research that discussed similar approach of determining microeconomic determinants of freight rates. We will also discuss research in the microlevel domain which used individual spot contracts and one particular research that explored handysize market segment in the CPP market. In the last part, we will discuss the methodology and model that will be employed in this thesis.

3.1 Context and Search Strategy

This chapter will discuss previous research in the same field of this research and also the methodological literature. In this thesis, freight rate studies in liquid bulk shipping published in academic journal are covered. To identify relevant literature, we mainly used Google Scholar as the search engine for journal by using keywords combination. We used keywords such as "tanker freight rates", "baltic freight index", "chartering", "oil transportation", and "econometrics".

These searches resulted in abundant amount of research papers, which eventually led to well-known databases such as Springer, Emerald, Science Direct, and Taylor & Francis. We then reviewed the title and abstract of the papers to conclude whether these papers are within the same topic of freight rate discussion, as this research does not include freight rates modelling. We found Alizadeh and Talley (2011a; 2011b) research in ScienceDirect which conducted a similar approach and field with this thesis. Although using a different dataset of freight market, we used these research as our main reference of framework to finalize this thesis.

3.2 Research Themes in Microeconomic Determinants of Freight Rates

In the freight analysis domain, the main focus has been on building an appropriate forecasting model to predict freight rate and a relationship analysis of tanker freight rates with macroeconomic factors. In this research, we aim to approach our analysis in a microeconomic level which do not use any exogenous variables. In this literature review section, we will focus on discussing literatures in the area that include micro level in the freight market domain that is also using individual contract data.

The most similar research that conduct market analysis at micro level with individual spot contract data were done by Alizadeh and Talley (2011a; 2011b). In that two research they did an analysis of freight rates with contract times and voyage determinants by examining individual spot data in the tanker market and dry bulk market. For the tanker market, they focus on the dirty segment which use larger vessel size in VLCC, Suezmax, and Aframax. They compiled a set of contract data with the total of 14,111 contracts. In the dry bulk segment, they limited their research on the Panamax and Capesize dataset which concluded by using 12,115 contract information.

In that two research, they both introduced a regression model as a simultaneous equation which will explain the freight rate as the dependent variable. The difference in the two research; however, the dependent variable in the tanker research is the freight rate of each individual contract while in the dry bulk segment, is the difference between the log freight rate and log of Baltic freight index. In both of the research, the study suggested that there is a positive relationship between laycan period and freight rates, which a longer laycan period is correlated with a higher freight rate. A high freight rate indicates a high demand of marine transportation which also indicates that there is a shortage of vessel supply in the market. Thus, charterer tends to fix the vessel earlier and willing to wait longer for vessel. With this behavior, they give a longer laycan period to secure their tonnage and to avoid any possibility of vessel shortage. In addition, vessel size and age have a correlation with freight rate. Older vessels generally have lower freight rates.

Another example of micro level domain in the freight market is conducted by Adland et al (2016). In their research, they used 2,863 contracts in the VLCC segment and 1,789 contracts in the Capesize segment. The significant difference that was done is by introducing a fixed effect on a specific charterer and ownership of the vessel. Thus, using a fixed effect regression model to see a specific interaction between entity, and quantify the interaction using variance decomposition. In their model, their dependent variable is the freight rate for each contract with several same independent variables such as vessel age, laycan period, route specific; however, they introduced a fixed variable to each charterer. The study found that while the vessel characteristics in the voyage determinant are significant to the freight rate, the charterer fixed effect is relatively large. In the VLCC market, using the charterer fixed effect explained 8.3% of the freight variation while in the Capesize market able to explain 10.5% of the variation. The study suggests while the market condition and vessel characteristics are a significant determinant, the specific combination of each charterer and owner in the market also contributes to the freight negotiation as certain entities represent reputation and market knowledge.

It is interesting to mention that there are several other research that use individual fixture data; however, indirectly unrelated to freight rate domain. A study by Agnolucci et al (2014) used dry bulk market of Panamax individual contract fixtures between 2007 and 2012. Combining with data of fleet register database which contains information of the vessel characteristics such as fuel consumption, bunker capacity, and speed, they analyzed using regression model the effect of energy efficiency on the charter rates and earning. The study found that only 40% of the financial saving gained by the shipowners are related to energy efficiency. This suggest that environmental topic is still an issue in the maritime industry as shipowner is not getting significant incentives to invest in energy related technologies. Another research with individual fixture information was done by Tamvakis & Thanopoulou (2000), in the dry bulk segment with Panamax and Capesize size. They used data in 1989, 1992, 1995, and 1996 as a representation of peak and trough market conditions. By dividing their dataset based on vessel age profile to below and above 15 years, there were no statistically significant difference in the freight rate for the two size categories.

Contrary to the previous finding, Köhn & Thanopoulou (2011) with individual fixture information, succeeded in unfolding a hypothesis of a quality-related segmentation in the dry bulk market. Using generalized additive model, the study used 2,328 fixtures data on Panamax size between 2003 and 2007 in the shipping boom period. The study suggested that a quality segmented charter existed, with a clear segmentation on a lower freight rate for vessels aged 15 years above. This is the opposite finding of Tamvakis & Thanopoulou (2000) as they research in 2000 that the finding of a two-tier market segmentation is inconclusive and unclear.

In addition to these individual contract approach, there is only a limited number of research in tanker freight rates in the CPP segment. In fact, to the best of author's knowledge, we could only find one research that solely focus on the area of CPP shipping segment. Laulajainen (2011) did a research by mapping vessel movement data of oil product shipments. He combined vessel movement data and vessel fixtures, which the vessel movement data was acquired from Lloyd's Marine Intelligence Unit. The study found that there are 11 clean fixture trading regions, with the handysize segment dominates the trade geography. Out of these 11 regions, the three dominant regions are North America, Europe, and Asia Pacific which captured 68% of the total traffic in the CPP shipments. The handysize segment has become an integrated network with a shipment frequency for a minimum once per week. While for the Panamax and Aframax, they mainly operated from the Middle East region and North Atlantic. He also found that there are trade imbalances that influenced different freight rates in these routes. Area like the Middle East, which is a production region, causes a higher demand for shipping services which drives up the freight rates. As production region have higher frequencies of export, it led to further trade imbalance which also drove up freight rates for the exports.

3.3 Methodological Model

Based on the attribute of these dataset, we can argue that the profile of the whole dataset for this research is a a panel data. According to Wooldridge (2024), panel data is a time series for each cross-sectional observation in the dataset and collected over few periods. Baltagi (2021) explained that panel data refers to a pooling of observations on a cross-section of individuals over a period of time. Panel data is used to account for the individual heterogeneity; while a pure time-series or cross-section analysis are not able to account for such heterogeneity and might run to a biased result. In addition, a pure time-series analysis had a probability of a collinearity between each independent variable. In panel data, a collinearity is less likely as the analysis will give more information and variability to generate a reliable estimation. The most common models used in panel data are fixed effects model and random effects model.

The research and application of fixed effects model and random effects model have begun as far as 1975. Da Silva (1975) tried to find an estimation of a linear relationship in a time series cross sectional data. A simpler regression model that has been widely used made simple assumptions that is no longer relevant in some extent. They ignored the probability of a serial correlation of a time effect. Based on this, he proposed two models with one model assuming that the linear relationship is affected by a random variables of a time invariant cross-sectional unit effect, while the second model treat the time invariant cross-sectional unit effects are considered fixed.

Bell & Jones (2015) explained the wide application of the two models. The fixed effects model is widely used in economics and political science, while the random effects model is used in broader sectors. It is used in political science, education, epidemiology, geography, and biomedical sciences. Both models are actually an applied model for microeconomic field which uses cross-sectional data (Wooldridge, 2024). The random effects model has been used in a wider application because in a large population, the model is able to account for a degree of freedom while the fixed effects model would lead to a high loss degree of freedom (Baltagi, 2021).

3.3.1 The Fixed Effects Model

As discussed in the previous paragraph, the data profile of our research is a panel data. Hence, we need to use appropriate model to do an analysis of panel data. Woodlridge (2024) described that fixed effects model and random effects model are the most widely used methods in an advance panel data analysis. The problem that often occurs in a panel data analysis is an unobserved heterogeneity which comes from a specific individual characteristic that influence the dependent variable; however, not directly measured in the data. In an advanced panel data analysis, the methods used is set to control the unobserved heterogeneity that is constant over time. The first model in advanced panel data analysis discusses how to eliminate this effect and shown on the following formula (Wooldridge, 2024).

$$y_{it} = \beta X_{it} + \alpha_i + u_{it}$$

y_{it} = the dependent variable for entity *i* at time *t*

β = the vector of coefficients

X_{it} = vector of independent variables

α_i = the unobserved individual-specific effect

u_{it} = the error term

To eliminate the fixed effects, we start with demeaning the variables by subtracting the individual-specific variable mean, from the each observation. This shows that for each *i* the time average for each equation is as follow.

$$\bar{y}_i = \beta_1 \bar{X}_i + \alpha_i + \bar{u}_{it}$$

As α_i is fixed over time, then we have to remove the α_i variable by subtracting the first model with the average of the equation as follow. The fixed effects transformation is also called within transformation as this method involves demeaning the variables of y and x for each entity *i* over time.

$$y_{it} - \bar{y}_i = \beta_1 (X_{it} - \bar{X}_i) + u_{it} - \bar{u}_{it}$$

Continuing the above equation, then we get the final equation of the fixed effect model after removing the fixed effect of α_i in the following equation where $\ddot{y}_{it} = y_{it} - \bar{y}_i$ is the time-demeaned data with the same definition applies for the $\ddot{x}_{it}$ and $\ddot{u}_{it}$

$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it} + \ddot{u}_{it}$$

In this research, we will have several independent variables to run simultaneously, to see how these variables affecting our dependent variable which is the BCTI. For a multivariate fixed effect estimation, the final formula will be as follow.

$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it1} + \beta_2 \ddot{x}_{it2} + \ldots.. + \beta_k \ddot{x}_{itk} + \ddot{u}_{it}$$

3.3.2 The Random Effects Model

Contrary to the fixed effects model where it assumes that controlling the unobserved heterogeneity is by removing it, the random effects model assumes that the α_i has zero mean and uncorrelated with any of the independent variable. This is done by introducing an intercept to make the zero-mean assumption. This model goes in the following formula (Wooldridge, 2024).

$$y_{it} = \beta_0 + \beta_1 X_{it1} + \ldots.. + \beta_k X_{itk} + \alpha_i + u_{it}$$

y_{it} = the dependent variable for entity *i* at time *t*

β_0 = the intercept coefficients

β_1 = the vector of coefficients

X_{it} = vector of independent variables

α_i = the unobserved individual-specific effect

u_{it} = the error term

To assume that the previous equation is a random effect model, then we must conclude that the α_i is truly uncorrelated with each of the independent variable. The ideal assumption is to include all of the fixed effect assumption with α_i as independent from all independent variables. The assumption that α_i is uncorrelated with each variable is explained in the following formula.

$$Cov\,(x_{itj}, \alpha_i) = 0, t = 1, 2, \ldots T; \; j = 1, 2, \ldots, k$$

Continuing with the assumption that α_i is uncorrelated with the independent variables, then we define the error as a composite error term, then our initial random effects model is transformed as follow.

$$y_{it} = \beta_0 + \beta_1 X_{it1} + \ldots.. + \beta_k X_{itk} + v_{it}$$

This is explained as again that α_i is the composite error in each period, the composite error term of the v_{it} is correlated over the time period. Under this assumption, there is a degree of correlation between error terms at a different time period for the same individual specific variable of i. Under panel data, v_{it} are comprised as two components which are α_i as the individual-specific effect and u_{it} as the idiosyncratic error. To express the degree of correlation between composite error terms, we can use the variance of these components which $\sigma_a^2 = Var(\alpha_i)$ and $\sigma_u^2 = Var(u_{it})$. The variance is expressed as follow.

$$Corr(v_{it}, v_{is}) = \frac{\sigma_a^2}{\sigma_a^2 + \sigma_u^2}, t \neq s$$

The positive serial correlation under an error term is significant, and under an Ordinary Least Squares model it neglects the error which will be invalid. To solve the issue of excluding the error correlation, the serial correlation issue can be fixed by using a Generalized Least Squares transformation by giving a value between 0 and 1 under the following formula.

$$\theta = 1 - \sqrt{\frac{\sigma_u^2}{\sigma_u^2 + T\sigma_a^2}}$$

After fixing the issue of excluding the serial error correlation, we get the transformed equation for the random effects model as follow.

$$y_{it} - \theta\bar{y}_i = \beta_0(1 - \theta) + \beta_1(X_{it1} - \theta\bar{X}_{i1}) + \ldots.. + \beta_k(X_{itk} - \theta\bar{X}_{ik}) + (v_{it} - \theta\bar{v}_i)$$

To summarize, the random effects allow a correlation between the unobserved specific effect with the independent variables while random effects model does not. Ultimately, choosing between either fixed effects model or random effects model depend on the profile of the data. Both models are still widely used in econometrics by researchers and compare the two models with a test to check the statistically differences (Wooldridge, 2024). In the application of the two models, the test used is the Hausman test which explained as follow.

$$H_0: Cov(\alpha_i, X_{it}) = 0$$

Under the null hypothesis of the Hausman test, the preferred model is the random effect which implies that the α_i as the individual-specific effect is uncorrelated with the independent variable. In contrast, the alternative hypothesis is that the fixed effect is more suitable which indicates that the α_i as the individual-specific effect is correlated with the independent variable. Thus,

$$H_1: Cov(\alpha_i, X_{it}) \neq 0$$

The interpretation of the Hausman test is seen by the p-value, whether the test is statistically significant or not. If the test is found significant at 5% level (p-value < 0.05), we then reject the null hypothesis, and the fixed effects model is more appropriate. If the test is insignificant at 5% level (p-value ≥ 0.05), we then will not reject the null hypothesis. Thus, the random effects will be chosen based on the test.

Chapter 4 Data Description and Exploratory

This chapter is comprised of three parts. In the first part, we will describe the raw data that we acquired from the database that we use. Following that, we will explain and visualize the data transformation that is done in this research with the theoretical background that is followed to do the transformation. In the last section, we will describe our final dataset and present the statistical summary of the data.

4.1 Raw Data

The data used for this analysis is acquired from SIN, a database provided by Clarkson Research Services Limited. As discussed in the previous chapters, this research is aimed to unfold the dynamics in the liquid clean petroleum market with focus on the handysize market. Therefore, we collected the spot fixtures information of clean handysize tanker voyages. In this portal, the available fixtures information is from 2021, 2022, 2023, and 2024. By the time this research is conducted, the latest reported fixtures are in June 2024. Therefore, this research will only use what is available in the portal. From the portal, the raw acquired number of fixtures information as follow:

Table 7. Raw Data Collection

Year	Count
2021	4,411
2022	3,871
2023	2,992
2024	1,089
Total	12,363

All datasets are provided with the same information and variables in the same order. There are 16 variables which in general comprised of vessel characteristics and fixtures information. The vessel characteristic categories are vessel name, year built of the vessel, deadweight tonnages size of the vessel, and hull type. Except for hull type, every available information in this hull type is always double hull. This finding is in accordance with the latest IMO regulation in July 1993 which later adopted as MARPOL in Annex I, that every international tanker voyage has to be built in double hull structure (Yip et al., 2011). While on the fixture’s information, it consists of commercial information that is negotiated in the fixture. The variables are date of the contract being fixed, quantity of the cargo, cargo characteristic which in this case every observation is clean product, type of cargo, charterer name, date of laydays, cancelling date, loading port, discharging port, freight rate, unit of the freight rate, and the ship owner name.

However, it is important to note that out of 12,363 observations, not all observations will be usable to do analysis as there are observations with either missing values or blank in one of the variables. Moreover, the value in the vessel name variables might be inserted; however, reported as “To be Nominated” (TBN). This might happen as the fixture might have been negotiated between the ship owner, charterer, and brokers; however, the fixture was never fixed. As a result, the negotiation still could reflect the market condition for certain cargo type and port rotation.

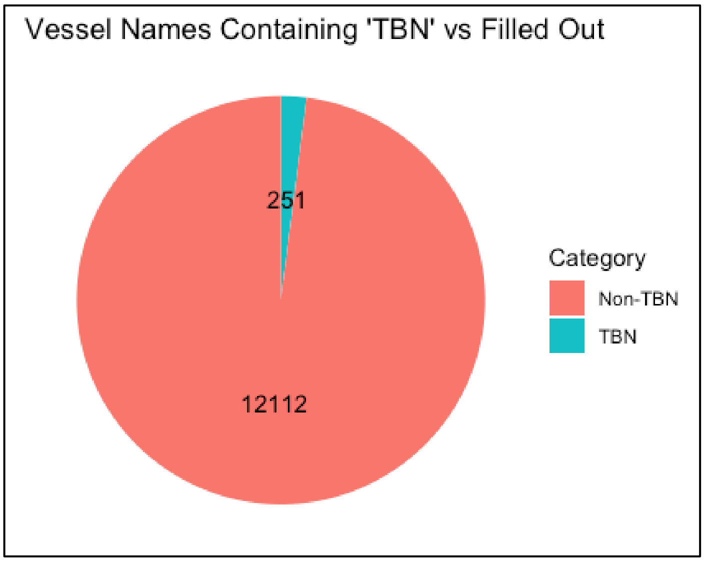

Figure 4. Pie Chart of TBN Vessels in the Dataset

After filtering the data, it is confirmed that in the vessel name there are no blank values. Instead, they all are written in TBN. The number of TBN names are 251 observations as depicted in the figure above. In these TBN observations, the rate is still reported although the vessel details are unknown and every port rotation information is still inserted, while out of 251 observations, there are 106 missing values in the “Rate” variable.

One more important variable in the dataset is the “Rate” variable. Freight rate is the sum amount of money being paid by the charterer to the ship owner, as a compensation to transport the cargo in the spot fixture. In dry bulk, the common freight rate unit is $/ton as the freight is calculated by the quantity of transported cargo. In the tanker market, there are still few that use $/ton for the freight while the most common unit are lumpsum and WS.

Regardless of the quantity, the freight is paid at a lumpsum amount. WS is a freight scale that is being used only in oil tankers sector and also in the product carriers. This scale helps stakeholders in the tanker chartering practice as this scale is using a standardized vessel at a

75,000 MT quantity which also includes port fee, bunker cost, and canal cost. Thus, negotiating in a WS scale will help to determine the earnings for ship owner and applicable to a certain port rotation (Worldscale Association (London) Limited & Worldscale Association (NYC) Inc., n.d.).

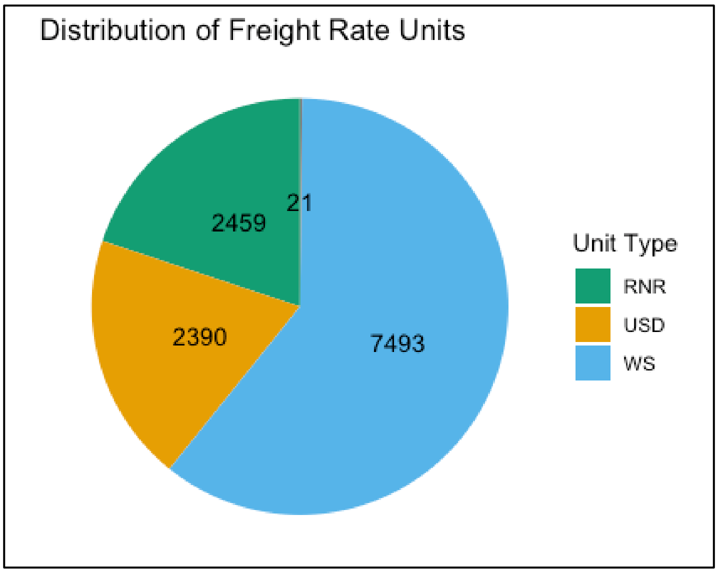

Figure 5. Pie Chart of Freight Rate Unit

To properly do the analysis, then we will need to have a uniform freight rates unit. It is also important to note that there are missing values in the rate variable. The blank values either come in a blank cell or written as “Rate Not Reported” (RNR). Based on the above figure, there are 7493 initial observations with WS unit, while missing rate values at 2459 as RNR and 21 filled blanks.

Lastly, we also acquired the BCTI index from SIN. As we will examine the price dynamics with individual spot contracts; thus, we collected the daily BCTI index. The reported index started on August 3rd, 1998, and last report was on July 11th, 2024. As our earliest fixture data is in 2021; therefore, we will only use the index from 2021 in our analysis which is in accordance with our available fixture data. After removing the irrelevant date, we now have 879 observations of daily BCTI index between the period of 2021 and 2024.

4.2 Data Transformation

4.2.1 Time and Geographical Element Variables

As discussed previously, there are initially 16 variables in the raw dataset. In these variables, the ones that consist of time elements are the contract date, the laydays date, and the cancelling date. Originally, the laydays date is named as “Laycan From” and cancelling date as “Laycan To”. These names are changed principally in accordance with the chartering terms where the first day of the laycan is called laydays and the last day of the laycan is called cancelling date.

Alizadeh and Talley (2011a; 2011b) explained in their research on tanker and dry bulk sectors that there is a time element effect on freight rate on their research that the duration of laycan period affecting the freight rate positively. Moreover, there is a tendency of vessel shortage in the market with a high freight rate. When this happens, the notice period between the fixture date and the laycan date is lower and also affecting the freight rate. In addition of the duration of laycan period, we also introduced a new variable which is the period of days between the fixing date and the first day of the laycan. With these two variables, we can explore the behavior of chartering tendency in the CPP handysize market and how this tendency is affecting the BCTI.

The two mentioned variables are both expressed in days. In addition to these two variables, we also introduced other variables which are also expressed in days. This variable is shipping time variable which is the time taken in days for vessel to complete the spot shipment from loading port to discharging port. In spot chartering, the revenue that the shipping companies want to achieve for every ship that they operate is often referred as Time Chartering Equivalent (TCE). This goes by the freight of the spot, deducted by the operating expense (OPEX) and divided by the total of the vessel rotation in days. In accordance with the TCE principle, hence, we can argue that the total days of the shipment will affect the price dynamics and freight rate in every spot shipment.

To do that, we must first find the distance between each loading port to discharging port in every observation in the dataset. However, there are too many routes combination from the raw dataset. Since this variable need to be acquired manually, it will take too much time to complete the variable. Initially, there are 312 loading ports which include blank observations and 317 discharging ports which includes blank observations as well. Together, this two information gave a total of 1597 combination of specific route in all datasets.

We then decided to group few areas into one region to avoid redundancy, saving time, and most importantly, we aim to capture a broader market information in a region to better understand the handysize market in general. We first looked into the information of Laulajainen’s (2011) research of handysize CPP market information. He found that there are generally 11 regions in the global market. These regions are East Coast North America, East Coast South America, Europe continent, West Africa, South Africa, Middle East Gulf, Far East, Australia, West Coast Nort America, West Coast South Asia, and Pacific Ocean.

However, we think that this region grouping is still too generic for few regions such as the Pacific Ocean, Middle East Gulf, and Europe continent. From this, we decided to split Europe continent into West Europe, UK continent, Black Sea, West Mediterranean, East Mediterranean, and Baltic. In addition, the Middle East Gulf is also expanded into Red Sea, West Asia, and East Africa. Based on this grouping, we got the total routes combination now at only 202 combinations which will make the distance calculation easier. The total routes combination can be found in Appendix I.

After deciding the region grouping, we calculated the distance between each region by using an application called “Netpass Distance”. This application is commonly used by shipping companies in their chartering department to calculate distance and voyage time, to do their freight calculation. To get the distance, we use the most common port in each region as the port reference to acquire the distance.

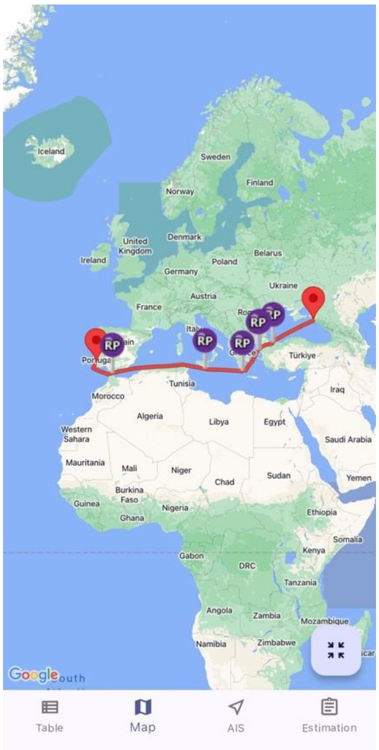

Figure 6. Netpass Distance Screen

The reference port in the loading port and discharging port are made different as we would like to capture market information from intra-regional trade. It is found that there are 15 intra-regional trade in the handysize segment. If we decided to use the same port for loading and discharging port, then we will not be able to get the shipping time for these regions. The port reference for each region can be found in Appendix II. Figure 6 above shows the screen and process of using the Netpass Distance application. In the table section, we simply put the port and discharging port name and also the desired speed. Once set, we can get the route illustration in the map section. In the figure, the example of the distance is between Novorossiysk (Black Sea) and Sines (West Europe). In the speed section, we found from SIN database that the average speed of handysize vessels is at 11 kts. Hence, in the shipping time calculation we put 11 kts in the speed to acquire the shipping time, by dividing the distance over speed of the vessels. We then convert the shipping time from hours into days.

Our last time-element variable is season. Poblacion (2015) explain in his research that seasonality occurs in the freight rate dynamics. By using weekly observations of spot and forward TCE in few tanker routes, he found that freight rates are higher in winter and spring seasons, compared with rates in summer and autumn. Hence, from this research, we can argue that seasonality does also have effect on price dynamics. Based on this, we introduced additional variable which shows the season when the laydays first commenced. This can be done on R studio by using "lubridate" package by simply transforming the dates into season.

4.2.2 Cargo Element Variables

In addition to time element variables, there is an important information that can be derived from the dataset which is the cargo element. The already available information of cargo related information are the quantity of the cargo and the cargo type in each spot contract. In addition of these two variables, we can create a new variable again which is the cargo ratios that is transported in each spot contract.

Adland et. al (2016) defined the vessel capacity utilization as the ratio of the cargo size divided by the deadweight tonnage (DWT) of the vessel and did the analysis of vessel capacity utilization's relation with freight rates. The study revealed that the DWT is the dominant determinants of freight rate; however, the capacity utilization positively affecting the freight rates. The study also revealed that smaller vessels have a tendency to have a lower capacity utilization. Based on this research, we can argue that cargo utilization has an impact on price dynamics of freight rates. The closest information that can be derived from the dataset regarding capacity utilization is by dividing the cargo quantity by the DWT of the vessel. DWT principally is regarded as the cargo carrying capacity of the vessel, although in the DWT calculation also includes other weight such as fuel, stores, ballast water, fresh water, and other consumable provisions. With the limited available information, we created this new variable of cargo ratio by dividing the DWT of the vessel.

4.2.3 Vessel Information Element Variables

One last element in this research is the vessel related variables. The only available information of vessel related variable is the name of the vessel, the year built, and the DWT.

However, we are not interested in each of the vessel's name as the independent variable; however, will be included in the model as the entity dimension in both fixed and random effect models. The DWT will be included as one of the independent variables in the vessel information model.

It has been mentioned in the literature review sections that DWT is an important determinant of freight rate. Thus, this will be included in the vessel information model. In addition, we can derive another vessel related information which is the age of the vessel. Year built is available in the dataset; however, does not entirely reflect a direct information in each observation. Many research that has been discussed concluded that vessel age is an important determinant in freight rate. Since this is another important variable, we can obtain and create this variable by deducting the year of the contract for each vessel with their year built variable.

4.2.4 Freight Rates Transformation

Figure 5 has shown that the freight rate in our dataset is not uniform. To properly use the model, we have to have a uniform unit of the freight rate. Otherwise, it might skew the analysis. Our dependent variable in the model will be the BCTI; hence, we have to convert our freight rate with the same unit as the BCTI. Alizadeh and Nomikos (2009) explained that the BCTI is quoted in the WS point. Thus, it will be the observations with the USD unit that will be converted to WS unit.

The WS database is accessible for free for university lecturers and students. It is available to use by contacting the WS organization by introducing our association and the purpose of the use. They will return with username and password to access the database for the student version. However, there is one limitation in the student version that the latest available rate is only in 2020. As our dataset comes in the span between 2021 – 2024, this freight conversion might slightly skew the distribution of the freight rate in the dataset.

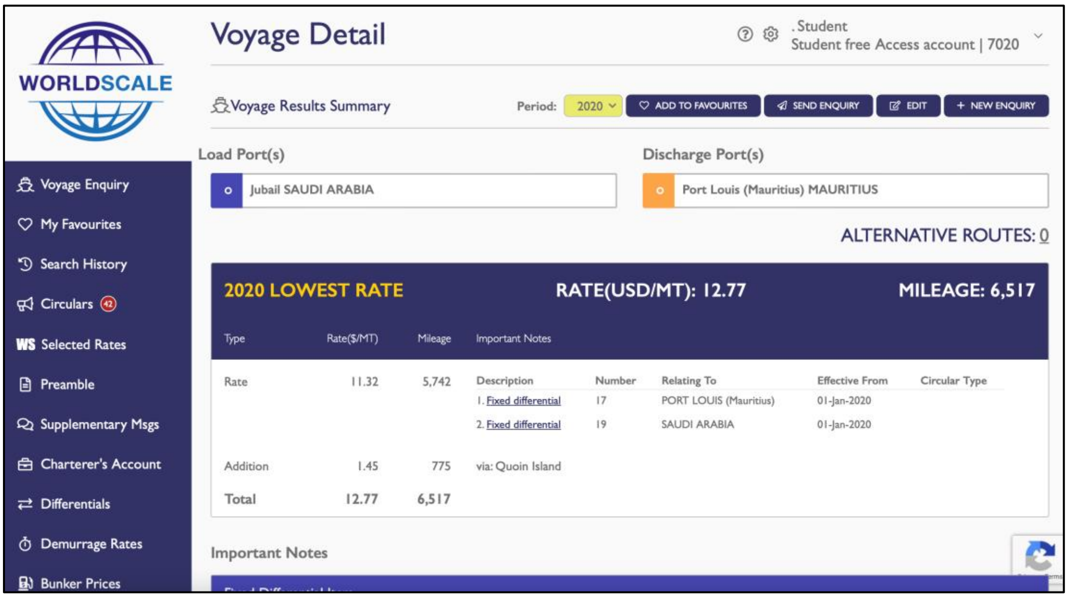

Figure 7. Worldscale Portal Access

In our model, the freight rate will be used in every model as an interaction term rather than solely as an independent variable. The BCTI is primarily associated with rate and cost; thus, the rate will be used as an interaction term between the index and the other independent variable. By applying rate as an interaction term, we can observe the relationship between rate and BCTI by other variables in each model.

The use of WS is by choosing the load ports and discharge port. In this process, we selected the route with the same port reference for each region. Once the route is quoted, the WS will return with a freight per metric ton. It is important to note that few port reference that was used to acquire the distance, does not have the WS freight. We used the closest port within the same region as the reference to acquire the WS freight as the WS are quoted with a standardized rate which also account for the bunker price, canal transit, and port dues. Once we have the freight per metric ton, we then convert the USD figures to WS figures. The standard WS figure is WS 100 which means the freight per metric ton is multiplied by the WS 100 as the WS 100 means 100%. This goes that the freight that will be paid is the full amount of the freight per metric ton that is quoted from the WS website. The quoted freight per metric ton per each route is then multiplied with the loaded quantity. The WS figure finally acquired by dividing the lumpsum USD freight rate from the dataset by the freight that is acquired from the WS multiplied with the loaded quantity. The multiplication is expressed as follow.

$$Loaded\ Quantity\ x\ freight\ per\ metric\ ton\ x\ \ WS\ \%\ =\ Lumpsum\ Freight\ (in\ USD)$$

4.3 Final Dataset

We have presented the data transformation and exploratory in section 4.2 which has been done in accordance with literature review. In this section, we will present the final dataset that will be used as the model based on the sub research questions which are time element, geography element, cargo element, and vessel information element. In our dataset, all the missing values in each variable are removed. The RNR observation is removed, as rate will be used as an interaction term to explain the BCTI. As RNR means not available, the observations with RNR are removed. Moreover, the daily BCTI from SIN is combined with our dataset of spot fixtures. As BCTI is our dependent variable, this needs to be completed. After combining the two datasets, there are 158 missing values of the BCTI. As we were unable to predict or calculate the index, we decided to remove these observations as BCTI is a crucial variable in our dataset.

In addition, we also removed all observations with missing values in the variables that will be used in our model. Apart from blank values in the dataset, there were also TBN vessels as discussed in section 4.1. The TBN observations did not provide information in the DWT, quantity, year built, and the cargo type. This means that we will not be able to acquire the vessel age and cargo ratios variable and unable to include in the cargo element model, cargo element model, and vessel information model. As this will not be possible to predict the information, we decided to remove these observations as well. Based on these decisions, our dataset is comprised of 9416 observations with complete information in every variable. Below table is the final variable in the dataset that are used to create new variables and will be used in the analysis.

Table 8. List of Variables in the Dataset

Variable	Definition
Date	Date when the contract was fixed
Name	Name of the vessel
Dwt	The Dwt size of the vessel
Quantity	Cargo quantity to be shipped in the contract
Cargo Type	Type of CPP transported in the contract
Loading Regions	The region of the loading port
Discharging Regions	The region of the discharging port
Route	The shipping route
Distance	Distance in nautical mile to perform the fixture

Shipping Time	Voyage time in days from loading port to discharging port
Rate	Freight rate in WS index
BCTI	The BCTI rate on the contract date
Laycan Duration	Laydays duration in days
Days between Contract Date and Laydays	The duration in days between contract date and the start of laydays
Vessel Age	The age of the vessel on each contract
Cargo Ratio	The ratio of cargo quantity/Dwt
Season	The season when the voyage is performed

4.3.1 Time Element Variables

In the time element variables, there are four variables with the three of them being a numerical variable. These variables are laycan duration, days between contract and laycan commencement, and shipping time. The only character variable in this model is the season which is transformed from the date of the voyage commencement. We first examined the statistical summary for the numerical variables in the time element dataset.

Table 9. Statistics Summary of Numeric Time Element Variables

Variable	Min	Median	Mean	Max	Observations
Laycan duration (days)	0	1	1.097	93	9416
Days between contract and laydays	0	6	6.349	186	9416
Shipping time (days)	0.791	5.704	8.924	44.507	9416

Based on the table above, we can infer that in the handysize CPP segment, there are voyages with that immediately performed as the minimal value of the laycan duration and days between contract and laycan is 0. According to Alizadeh and Talley (2011a; 2011b), these types of voyages are the ones that tends to have a higher freight rate, as the charterer is forced to make a quick decision in their transportation. They did not have the time to source for suitable and hoped for and thus, they need to settle for less quality vessel as their loading window with their receiver's end that will due soon.

In the meantime, we can also infer from the max values for both variables that there are voyages that have the laycan duration up to three months and have a voyage that has been fixed up to six months prior to the loading date. According to Alizadeh and Talley (2011a; 2011b), this is the behavior that is shown by charterers who have a flexibility in their transportation cost as higher laycan duration and contract waiting time are associated with higher freight rates. They are willing to secure their tonnage earlier to avoid tonnage shortage, closer to their loading window of their cargo.

In addition, we can see from the shipping time variables that there is a wide range of shipping time in the handysize segment. Stopford (2008) explained that handysize is mostly used for regional trade; hence, needing only minimum time. However, we also see here that handysize is occasionally used for a longer distance as well.

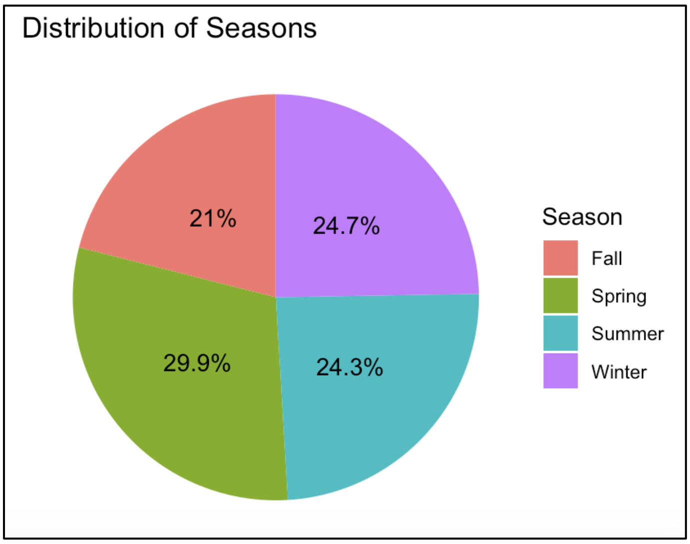

Figure 8. Pie Chart of Season

Figure 8 above depicts the distribution of seasons in the spot fixture of handysize. The season is almost distributed evenly across all seasons with spring with the highest portion in the dataset. It is also important to mention that there is no seasonal difference in the laycan period. It is seen from the mean of laycan duration in is only one day and the three months laycan period is still within the same season. In the analysis, for doing a regression analysis with a character variable, one category must be categorized as a reference for the other character variables. As literature shown that higher freight rates are commonly in winter season, we decided to put winter as our reference in the analysis.

4.3.2 Geographical Element Variables

The geographical element variables in the dataset are all character variable. Figure 9 and 10 below show the distribution of loading and discharging region in the dataset. It has been mentioned in section 4.2.1 that we decided to group the ports as they were too many combinations. In addition, we would like to capture a bigger map of handysize transportation by grouping the voyages regionally.

Figure 9 shows that most loading region in the dataset was loaded in the East Mediterranean region. Routing wise, most frequent route in the dataset was the East Mediterranean - West Mediterranean route. The Middle East region, being a country with the biggest exported oil is not in the top 7 list of loading region, is categorized as other with the remainder of loading regions that we created. This shows that the Middle East exports are transported in a higher vessel size, at least in the past four years.

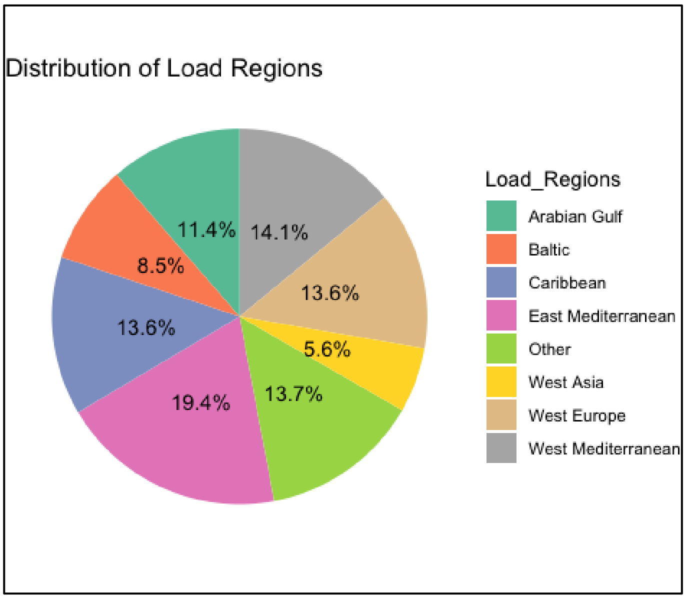

Figure 9. Pie Chart of Loading Regions

Figure 10 below shows the distribution of discharging regions in the dataset. The chart shows the top 7 list while the remainder regions are categorized in other. We can see clearly that 30.6% of the fixtures are discharged in the West Mediterranean region. On the other hand, the remainder regions only accounts for 17.3% of the total regions as the discharging port.

The European region is all accounted in the discharging region. We can see that apart from West Mediterranean that comprised of region such as South Spain, South France, and Italy, we also see the UK Continent region, West Europe, and Baltic region in the top discharging regions. This shows that the European region is importing a high quantity of CPP cargo, at the size of handy vessels.

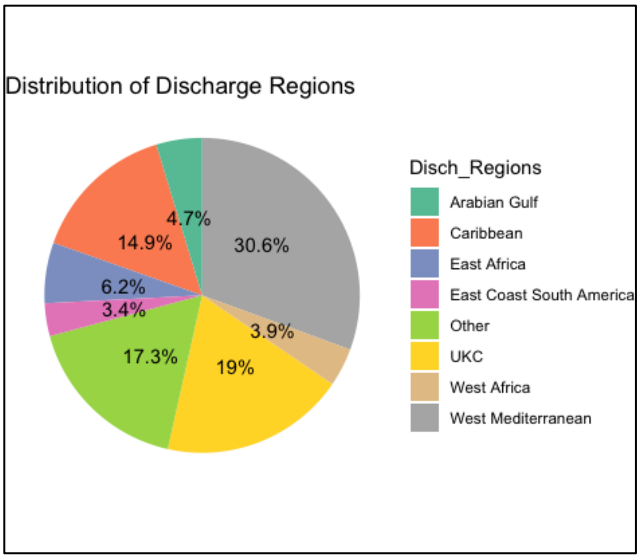

Figure 10. Pie Chart of Discharging Regions

Lastly, in this analysis it would be difficult to examine on each specific route as we have 212 routes. If we run all variables in the model, the possibility of high correlation might occur. Hence, we selected few routes based on the cumulative frequency of all routes. The specific routes that were taken into the model represents 65% of all available routes in the dataset. The remaining 35% routes are categorized as "other" in the dataset and used as the reference and baseline in the route category. This approach is the same approach that Alizadeh and Talley (2011a) did as they only included 14 routes for the VLCC market that represented 75% of all the fixtures in the dataset. These routes in our model can be found in Table 10 below.

Table 10. Specific Routes Used in the Model

Routes	No of Fixtures	Cumulative Ratio
East Mediterranean - West Mediterranean	1259	13%
West Mediterranean - West Mediterranean	989	24%
Caribbean - Caribbean	582	30%
Baltic - UKC	490	35%
West Europe - UKC	462	40%
Black sea - West Mediterranean	362	44%
Arabian Gulf - East Africa	358	48%
West Europe - Caribbean	347	51%
Arabian Gulf - Arabian Gulf	288	55%
Caribbean - UKC	218	57%
Caribbean - West Coast South America	201	59%
East Mediterranean - UKC	185	61%
West Mediterranean - UKC	177	63%
Caribbean - East Coast South America	176	65%

Other	3322	100%

The next variable in the geographical element is distance. We have shownin section 4.2.1 the process of acquiring the distance in each route. As we have grouped the route based on the contract frequencies, it is important to still keep the effect of these geographical routes by its distances. Below table depicts the statistical summary of the distance variable.

Table 11. Statistical Summary of Distance Variable

Variable	Min	Median	Mean	Max	Observations
Distance (nm)	209	1506	2356.153	11750	9416

4.3.3 Cargo Element Variables

The cargo element variables are comprised of two numerical variables which are cargo quantity and cargo ratio. There is one character variable in the dataset which is the type of cargo. In the dataset, there are 13 types of cargo available in the dataset. These 13 types are aviation diesel oil, condensate, CPP, diesel, diesel oil, gasoil, jetoil, light cycle oil, mogas, naphtha, reformate, ultra-low sulfur diesel, and unleaded motor spirit. Figure 11 below shows that the most transported cargo is ultra-low sulfur diesel, followed by unleaded motor spirit. Unleaded motor spirit is a type of unleaded gasoline which in the refining process did not use any additive in the process. This type of additive that is used in oil refining is called as “lead”. Lead was first used in 1923 by putting tetraethyl lead as a cheap process to boost octane in the mixture (Sperling & Dill, 1988). Thus, the unleaded motor spirit is the gasoline that is produced without any additional additive in the mixture.

We consider CPP as a wide range of category that has been put in the first place from the database. As it is impossible to estimate the exact type of cargo, we left it as it is in the dataset as it only accounted for 16% in the dataset. Across all 13 types, the highest price of the CPP commodity is the jetoil. However, the quantity is not significant as it is categorized with the remainder eight cargoes in the “other” category which only accounted for 8.4%.

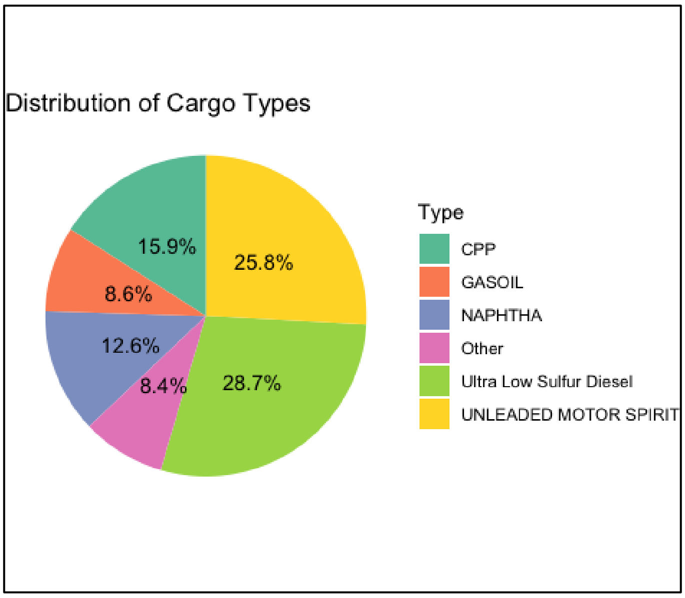

Figure 11. Pie Chart of Types of Cargo

We can further interpret from the statistics that handysize vessel is also used to transport relatively a small quantity at 3,000 MT. In the dataset, there are two observations with the 3,000 MT quantity and a total of 12 observations with the loaded quantity at less than 10,000 MT. We decided to use the benefit of the doubt that these observations are not a typo-reported observations by SIN as if there was an additional 0 in the quantity, the quantity will be bigger than the DWT size which would be impossible. The average quantity of handysize is transporting around 33k MT of cargo, while the highest loaded quantity is at 45k MT. We can argue that there is no outlier in the quantity variables other than the 12 observations as the handysize vessel is segmented between 10k – 60k DWT.

In addition, we can interpret that the average cargo utilization of handysize tankers is only at 75% of its DWT. Stopford (2008) explained that the average cargo utilization of tanker is at 96% of the vessel's DWT size. Hence, we can argue from the statistic below that the handysize segment is under-utilized as the average is at 75%.

Table 12. Statistics Summary of Numeric Cargo Element Variables

Variable	Min	Median	Mean	Max	Observations
Quantity (MT)	3000	35000	33657.37	45000	9416
Cargo Ratio	6.27%	75.26%	75.64%	97.82%	9416

4.3.4 Vessel Information Element Variables

The final element in our dataset is the vessel information variables. The first variable is the vessel age which was acquired by subtracting the year of the contract with the year built of the vessel. The minimum age in the statistic shows 0 which means that the vessel is performing its early voyages after the vessel has been built. The contract is performed in the same year of the vessel being delivered. We can also interpret that the average age of handysize vessel in the market is 10 years old which is relatively young.

Oil major charterers are now stringent as in their vetting assessment, vessel older than 15 years of age are required to have a Condition Assessment Program (CAP) survey. Having no CAP certificate means that the vessel is capped with observations in their vetting assessment. This shows that the market of handysize vessel is fulfilling the oil major's requirement.

The final variable is the DWT. From the statistics, we can infer that the average size of handysize vessels in the market is at 44k – 46k tons. The size segment of handysize is between 10k – 60k DWT. Hence, there is no significant outlier and miss-reported size in the handysize final dataset.

Table 13. Statistics Summary of Numeric Vessel Element Variables

Variable	Min	Median	Mean	Max	Observations
Vessel Age	0	12	10.78	31	9416
DWT	10776	46652	44706.05	55202	9416

Chapter 5 Results and Discussions

In this chapter, we present and discuss the results obtained from the model explained in section 4.2. The model is derived from the literature review and in this chapter, we will discuss the result per each model proposed to each sub-research question. We will also discuss the analysis and the result interpretation concerning the price dynamics of the BCTI in this research. Four tables are presented, each showing the statistical result of each model. These tables include signs that represent the magnitude of the testing. Three asterisks (***) indicates that the p-value is less than 0.001 which indicates highly statistically significant at 0.1% level. Two asterisks (**) indicates the p-value is between 0.001 and 0.01 which is statistically significant at 1% level. One asterisk (*) indicates the p-value is between 0.01 and 0.05 which suggests the significance at 5% level. The (^) sign indicates marginal significance at 10% level, while no sign next to the coefficient value means no statistical significance.

5.1 Time Element and BCTI Price Dynamics

The first sub-research question is how the time elements in the dataset affect the BCTI price dynamics. In chapter 4, we explained that all the time element variables in this model are derived from the original information in the dataset, such as the laycan time frame and the contract date. In this time element model, we derived four variables and the model outputs from the panel data analysis of fixed effects and random effects are shown in Table 12.

Table 14. Time Element Model Output and Comparison

Variables	Fixed Effects	Random Effects
Rate	1.881*** (0.024)	1.649*** (0.021)
Laycan Duration	6.943*** (1.399)	7.454*** (1.376)
Days between contract and laydays	-2.103** (0.654)	-1.996** (0.628)
Shipping Time	4.361*** (0.505)	3.924*** (0.446)
Season Fall	15.730^ (8.640)	17.324* (8.407)
Season Spring	12.055 (7.931)	10.357 (7.695)
Season Summer	-17.840* (8.389)	-7.585 (8.118)
Constant		434.396*** (10.361)
Observations	9416	9416
R-squared	0.444	0.484
Adjusted R-squared	0.324	0.483

Significance codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘^’ 0.1 ‘ ’ 1

In time elements model, both fixed effects and random effects models show similar result with small differences in few variables. Rate, laycan duration, days between contract and laydays, and shipping time show the same significance level with varying coefficient level. We explained that in this model for the season variable, we use winter as the reference factor, as literature indicates that freight rates are often higher in winter. From the models, fall season shows a different significance level from both models, while only fixed effects show a significance level for summer season, as the random effects does not consider summer significance.

To further interpret further these results, we conducted the Hausman test to decide which model should be used for the analysis. The Hausman test for this model shows a p-value of 2.22e-16, indicating that the test is significant at 5% level with the p-value is less than 0.05. From this statistical test, we reject the null hypothesis and choose the fixed effects model as the applicable model. The result interpretation will be discussed in accordance with the test result of the fixed effects model.

The rate variable is introduced in the model as an interaction term to see the effect on the BCTI by comparing with other models of element in the sub-research question. This variable is significant with positive coefficient of 1.881. This shows if the rate is increased by 1 point of WS, the BCTI also increases by 1.881 points. This suggests that rate affects price dynamics in the BCTI and CPP segment, which is unsurprising as the BCTI is a compound index of average freight rates on major routes defined by the Baltic panelist.

The first variable, laycan duration indicates a positive effect on BCTI. This variable is considered significant at the 0.1% level according to the test result. This shows that if the laycan duration increases by one day, the BCTI increases by 6.9 points in the index by keeping other variables constant in the model. From this model, we can interpret that laycan duration affects price dynamics and the freight rate, implying that a longer laycan duration influences a higher rate in the CPP handysize segment. This finding aligns with the literature review that suggests a longer laycan period positively affects freight rates, implying that the charterer is keen to fix the vessel earlier while giving a longer laycan period to shipowner by securing their tonnage in advance.

The second variable is the duration between contract date and the laydays commencement. This variable is significant at the 1% with the coefficient of -2.1. This suggests that if we increase the duration between the contract date and the laycan commencement date by one day, the BCTI decreases by -2.1 points by keeping other variables constant. Contrary to the laycan duration variable, if the tonnage is secured well in advance by the charterer, the charterer could pay a lower freight rate. The panel data analysis is a linear regression analysis which is designed for panel dataset. This contradictory finding might suggest that the interaction between laycan duration and days between contract and laydays might be non-linear or that these two time-element variables are in a different time horizons. While laycan duration represents the loading flexibility, the period between contract date and laycan commencement shows how far in advance the contract is agreed. However, from this analysis, we can interpret that a longer duration between contract date and laycan commencement negatively affect the price dynamics, implying a lower freight rate is agreed if the tonnage is secure early.

The third variable in this model is shipping time. In this analysis, shipping time is the time taken in days to conclude the voyage from the loading port to the discharging port. The model suggests that shipping time is also significant at the 0.1% level with a positive coefficient of 4.36. This suggests that if the shipping time increases by one day, the BCTI also increases by 4.36 points, indicating that a longer distance is associated with a higher freight rate. This finding is unsurprising, as the component of freight rate calculated by the shipowner includes the bunker cost from consumption. A longer distance means more fuel consumption; hence, a higher freight rate needs to be compensated.

The next variable in this model is season. In this model, we used winter as the reference to conduct the analysis for the character variable. We chose winter as literature shows that higher freight rates occur in the winter season. From this output, we can infer that summer is statistically significant at the 5% level, and fall at the 10% level. Hence, we can only interpret summer as the only season showing statistical significance, albeit at 5%. The summer coefficient shows -17.84, suggesting that the BCTI, on average, is lower by 17.84 points compared to winter. Fall and spring show positive coefficients but are statistically insignificant. Based on this output, we can infer that the winter season has relatively higher freight rates compared to the summer season. We could interpret that the transportation demand for CPP is relatively lower in the summer season compared to winter, resulting in lower freight rates. However, we cannot fully conclude that seasonality exists based on this analytical approach, although many literatures show seasonality research on freight rates. According to this result, we can only conclude that seasonality exists between summer and winter, which shows a six-month cycle between summer and winter.

5.2 Cargo Element and BCTI Price Dynamics

In this model, there are three variables: cargo type, cargo quantity, and cargo ratio, with cargo type as the only character variable in the model. For this character variable, many observations reported CPP as the cargo type. There was no specific cargo type reported in these observations, with only CPP being mentioned. As this type became too generic, we decided to use it as the reference for the cargo type variable.

Before conducting the analysis, it is important to check the correlation values between each cargo type. A Pearson correlation test was conducted for these variables, and most results show negligible correlation, while a few have weak correlations. These values and plots can be seen in Appendix III. Schober et al. (2018) explained the conventional approach to interpreting the coefficient. The range is between -1 and 1 to conclude perfect correlation. The highest value in the test was found at -0.37455425 between unleaded motor spirit and ultra-low sulfur diesel, indicating a weak correlation between these two variables.

We further checked for multicollinearity in this full model prior to conducting the regression analysis. Unlike in the previous model, the suspicion of multicollinearity in this model exists because of the variable nature. These cargo variables are derivative products from crude oil and are highly influenced by oil prices; hence, multicollinearity is suspected beforehand. The most common test to check for multicollinearity between two or more independent variables is the Variance Inflation Factor (VIF) (Wooldridge, 2024). The common interpretation is that if the VIF value is below 5, it indicates low multicollinearity, while a VIF value above 10 indicates that multicollinearity is a problem in the regression model. The VIF results for this model can be found in Appendix IV, which shows that multicollinearity does not occur in this cargo element model.

Table 15. Cargo Element Model Output and Comparison

Variables	Fixed Effects	Random Effects
Rate	1.900*** (0.024)	1.671*** (0.021)
Aviation Diesel Oil	-167.190 (149.770)	-195.610 (153.920)
Condensate	25.353 (30.840)	9.957 (30.143)
Diesel	28.355 (50.365)	43.936 (47.762)
Diesel Oil	-4.327 (36.644)	6.786 (34.679)
Gasoil	-17.352 (12.890)	-19.818 (12.457)
Jet	2.621 (15.057)	-16.946 (14.626)
Light Cycle Oil	278.920* (131.370)	243.670* (106.590)
Mogas	-314.660 (267.850)	-226.070 (271.620)
Naphtha	46.999*** (11.563)	39.236*** (11.050)
Reformate	-23.539 (28.114)	-18.852 (27.164)
Ultra low Sulfur Diesel	7.602 (9.876)	5.809 (9.448)
Unleaded Motor Spirit	23.888* (9.812)	25.921** (9.236)
Quantity	0.010 (0.007)	0.003** (0.001)
Cargo Ratio	378.310 (377.250)	537.460*** (67.599)
Constant		-60.990 (48.963)
Observations	9416	9416
R-squared	0.44822	0.48694
Adjusted R-squared	0.3282	0.48612

Significance codes:

0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘^’ 0.1 ‘ ’ 1

To decide which results can be interpreted, a Hausman test is conducted to determine which model is more appropriate for these variables. In our statistical analysis, the Hausman test produced a p-value of 2.22e-16, which falls well below the critical threshold of 0.05. This result demonstrates strong statistical significance at the 5% confidence level. Given this outcome, we were required to reject the null hypothesis and conclude that the fixed effects model is the most appropriate for this model. Consequently, our forthcoming discussion and interpretation of results will be grounded in the findings generated by this fixed effects model.

In this model, the rate is applied as an interaction term for the independent variables. The coefficient of the rate in this model is fairly similar to the previous model, with a positive coefficient of 1.9. When the rate increases by 1 WS point, the BCTI increases by 1.9 points. This shows that the rate positively affects the price dynamics of the BCTI.

We first examine the cargo type variables in the model. As this is a character variable, each category is assessed by the model. Out of 12 categories, only naphtha is statistically significant at the 0.1% level, while light cycle oil and unleaded motor spirit are significant at the 5% level. This finding suggests that these three cargo types command a higher freight rate and higher BCTI index compared to the generic CPP cargo type in the market. However, we faced unexpected outcomes with aviation diesel oil and jet oil. If we compare these two cargoes with freight rates, these two cargoes are expected to have a higher freight rate in each spot contract. Aviation and jet oil are known for their stringent tank cleanliness requirements (Schmidt, 1994). Improper tank cleaning from the last immediate previous cargo might affect the jet fuel’s freeze point. The quality of jet or aviation oil is strictly controlled to prevent engine failures of airplanes; thus, it is essential to control the tank suitability of the carrying vessel (Fox, 2016). As our dependent variable is the BCTI, we can interpret that jet and aviation oil are not the main components in the index calculation and are in small distribution quantities in the market. This finding is not directly related to the freight rate dynamics but mainly to the BCTI.

The next variable in this model is cargo quantity. The output revealed that this variable is insignificant with a relatively small coefficient in this model. This suggests that regardless of the cargo quantity, it does not affect the freight rate and the price dynamics of the BCTI. The same analysis applies to the cargo ratio variable. The cargo ratio variable is insignificant in this model. The literature argues that cargo ratio is a strong determinant of freight rates, particularly in dry bulk shipments, especially in iron ore shipments. This shows that cargo utilization capacity is irrelevant in the CPP handysize segment. We also found from the statistical summary that there are few handysize contracts that transported cargo quantities from the small tankers segment. This indicates that cargo quantity and capacity utilization are irrelevant in the handysize segment, in contrast with larger vessel sizes such as capesize and VLCC.

5.3 Vessel Element and BCTI Price Dynamics

The next model is the vessel element variable. This model is proposed to answer the sub-research question of how the vessel information elements in the dataset affect the price dynamics in the BCTI. In this vessel element model, we have derived the vessel age variables while the DWT is readily available in many observations. These variables and the model outputs from the panel data analysis of fixed effects and random effects are shown in Table 14.

Table 16. Vessel Element Model Output and Comparison

Variables	Fixed Effects	Random Effects
Rate	1.769*** (0.024)	1.629*** (0.021)
Vessel Age	46.047*** (3.321)	-1.587^ (0.896)
Dwt	0.030*** (0.005)	-0.00124 (0.001)
Constant		553.730*** (46.426)
Observations	9416	9416
R-squared	0.448	0.477
Adjusted R-squared	0.329	0.478

Significance codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '^' 0.1 ' ' 1

In this model, both fixed effects and random effects models show similar results with small differences in a few variables. The rate in both models is shown with the same significance level but different coefficient levels. Vessel age is more significant in the fixed effects model at the 0.1% level, while in random effects, it is significant only at the 10% level. DWT is only significant in the fixed effects model.

To further discuss our findings, we employed the Hausman test to determine the most appropriate analytical model. The test yielded a p-value of 2.22e-16, which is notably lower than 0.05, indicating statistical significance at the 5% level. This outcome led us to reject the null hypothesis and opt for the fixed effects model as the most suitable approach for our analysis. Our subsequent interpretation of the results will be based on the outcomes derived from the fixed effects model.

The rate variable is also introduced in this model as an interaction term. The result shows the same significance level with a similar positive coefficient value of 1.769. If the rate is increased by 1 WS point, the BCTI is increased by 1.769 points. This shows that the rate is positively affecting the price dynamics of BCTI.

The first variable in this model is vessel age. The model suggests that vessel age is significant at the 0.1% level with a positive coefficient of 46.047. This suggests that if the vessel age is increased by one year, the BCTI is also increased by 46.047 points. This finding suggests that older vessels are associated with higher BCTI and freight rates. This can be interpreted as older vessels operating with higher OPEX costs. Thus, higher freight rates need to be charged by owners to cover the OPEX.

The final variable in the model is DWT. The model also suggests that this variable is significant at the 0.1% level with a small positive coefficient of 0.03. This suggests if the DWT is increased by 1, the BCTI is only increased by 0.03 index points. Stopford (2008) argued that economies of scale persist in bulk shipping. As vessel size increases, the unit cost of transporting cargo per ton will decrease with the economies of scale principle. However, based on this finding, we can conclude that the effect of economies of scale in the handysize segment is relatively small with a coefficient of only 0.03.

5.4 Geographical Element and BCTI Price Dynamics

The final model in our analysis is the geographical element. As discussed in section 4.3.2, we kept 14 routes with a cumulative frequency ratio of 65%, while the other 35% of the routes are grouped into an "other" category. This category is used as the reference in the analysis to compare routes with higher fixture counts to those with lower frequencies.

The same statistical testing needs to be done for this element, as it contains many character variables which could lead to collinearity. A Pearson correlation test was conducted for these variables, and most results show negligible correlation, while a few have weak correlation. These values and plots can be seen in Appendix V. The same correlation interpretation is used according to Schober et al. (2018). The highest value in the test was found at -0.290065 between the "other" route and the EM – WM route. According to the table interpretation, this shows a weak correlation between these two variables.

We further checked for multicollinearity in this full model prior to conducting the regression analysis. It is important to note that we grouped 188 routes into a single category. Hence, multicollinearity might occur in this model due to the route variable. The VIF results for this model can be found in Appendix IV, which shows that multicollinearity does not occur in this geographical element model. For the route variable, we might take into account the normalized value of the VIF to account for the degrees of freedom as it contains 15 variables. With the normalized VIF, the value is even lower, and we can conclude that multicollinearity does not occur in this model.

Table 17. Geographical Element Model Output and Comparison

Variables	**Fixed Effects**	**Random Effects**
Rate	1.959*** (0.024)	1.736*** (0.021)
AG – AG	-197.750*** (20.320)	-239.680*** (18.705)
AG – East Africa	-13.558 (17.041)	-17.294 (15.597)
Baltic – UKC	-74.129*** (15.920)	-55.828*** (15.139)
Black Sea – West Mediterranean	-164.160*** (17.794)	-136.280*** (16.492)
Caribbean – Caribbean	100.010*** (16.399)	93.162*** (14.220)
Caribbean – ECSA	36.009 (23.110)	30.491 (21.289)
Caribbean – UKC	131.430*** (20.493)	126.030*** (19.228)
Caribbean – WCSA	-78.892*** (22.177)	-50.015* (20.246)
East Mediterranean – UKC	-8.228 (21.050)	25.114 (20.512)
East Mediterranean – West Mediterranean	0.786 (12.679)	37.593*** (11.115)
West Europe – Caribbean	37.730* (17.141)	38.360* (15.689)
West Europe – UKC	71.745*** (15.993)	105.350*** (15.336)
West Mediterranean – UKC	53.882* (22.047)	60.933** (21.272)
West Mediterranean – West Mediterranean	41.803** (13.306)	73.227*** (12.287)
Distance	0.018*** (0.002)	0.016*** (0.002)
Constant		399.060*** (10.968)
Observations	9416	9416
R-squared	0.470	0.508
Adjusted R-squared	0.355	0.507

Significance codes:
0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘^’ 0.1 ‘ ’ 1

A Hausman test was also conducted to determine the most appropriate analytical model. The test resulted in a p-value of 2.22e-16, which is notably lower than 0.05, indicating statistical significance at the 5% level. This outcome led us to reject the null hypothesis and choose the fixed effects model as the most suitable approach for our analysis. The analysis of this model will also be based on the fixed effects model result.

In this model, the rate variable showed a positive coefficient level of 1.959. If the rate is increased by 1 WS point, the BCTI is also increased by 1.959 points. This shows that the rate is positively affecting the price dynamics of BCTI.

The first finding from the model is that every shipment transported from the East Mediterranean is found to be insignificant. This suggests that these routes' impact on the BCTI is not significantly different from the other routes in the "other" category. The same interpretation applies to AG – East Africa and Caribbean – ECSA routes, indicating an average market condition without significant influence on freight rates and the BCTI.

Out of the 14 routes, 6 routes indicate a positive coefficient with high statistical significance level. These are the intra West Mediterranean and Caribbean trade, West Europe – UKC, West Europe – Caribbean, Caribbean – UKC, and West Mediterranean – UKC routes. The highest coefficient level is shown in the Caribbean – UKC route at 131.430. This suggests that this route is more favorable compared to the other routes available in the handysize segment. There is also an indication of strong transportation demand on this route, which drives the freight rate higher.

On the other hand, there are 4 routes with negative coefficients with high statistical significance levels. These routes are the Baltic – UKC, Black Sea – West Mediterranean, intra AG trade, and Caribbean – WCSA routes. The lowest coefficient level is shown in the intra AG trade at -197.750, which indicates that this route is highly unfavorable. Table 10 shows the cumulative ratio of the major routes in the handysize segment, and the intra AG trade depicts that this route represents 4% of the total handysize contracts. This also indicates a possibility of oversupply in the AG region, which led to lower freight rates.

The last variable in this model is distance. This variable is found to be significant at the 0.1% level with a coefficient of 0.018. This finding suggests that longer distances are associated with a higher index and freight rates. However, it is important to note that the effect of 0.018 in the increase of distance is from a longer distance of 1 nautical mile only. With an average speed of 11 knots, this would have been achieved in 5.45 minutes. The longer the distance by 1 nautical mile, the BCTI is increased by 0.018 points.

Chapter 6 Conclusion

This final chapter of the thesis will be concluded in several parts. The first parts will be the sub-research question discussion in accordance with the analysis result in chapter 5. Following that, we will discuss the limitation and difficulties that was experienced in this research. Lastly, we will suggest the further improvement and research that can be conducted based on the results of this research.

It is important to note that in the analysis we used two common models of panel data analysis which are fixed effects model and random effects model. To decide the model that is more suitable to represent the analysis, we conducted a statistical test called Hausman test. Across four models, every Hausman test concluded that fixed effects model should be used for all of the analysis. The sub research discussions in the following section are described in accordance with the result of the fixed effects model.

6.1 Sub Research Questions Discussion

6.1.1 Sub Research Question Number 1

The first sub research question discusses how the time elements information in the spot contract is affecting the price dynamic of BCTI. From the model, we derived four elements in the time element, which is laycan duration, period between contract date and laycan commencement, shipping time, and seasons.

From our research, we can conclude that the laycan duration is positively affecting the price dynamic of BCTI. The longer the laycan duration in the contract, the BCTI is concluded in a higher index. This gives insight that the freight rate is also higher when the laycan duration is higher. This finding is in line with Alizadeh and Talley (2011a; 2011b) findings in both crude tankers and bulk carriers market that a longer laycan duration is associated with higher freight rates. This could indicate that charterers are willing to pay premium of higher freight rates by securing the tonnage earlier in advance.

The second element in this model is the duration between contract date and laycan commencement. Our finding suggests that the longer the period, the BCTI is associated with a lower index. This suggests that a freight rate discount is often offered by shipowner if the tonnage is secured earlier. From shipowner’s perspective, a continuous employment is essential to guarantee the cashflow of the vessel in order to continue operate the vessel. When they have a fixed contract in hand for a certain period in the future, this is a guaranteed income that is essential for shipowner.

The third element in this first model is the shipping time. This variable is described as the total days taken at sea for each contract to be performed, defined in days. The result suggests that this variable positively affecting the BCTI dynamic. This finding indicates that a longer shipping time at sea is associated with a higher BCTI. This is mainly influenced by a higher freight rate as a consequence from a longer distance with additional bunker cost that needs to be compensated by ship owners.

The final element is season. Season is acquired by transforming the laycan dates into the season of the dates. Winter season is taken as the reference in the model to compare with the other season, as literatures suggest that freight rates are higher in winter season. The result suggests that only summer is considered significant at 5% level and shows that summer season is associated with a lower BCTI. However, we are unable to fully conclude the existence of seasonality in BCTI as fall is only significant at 10% level while spring does not show any significance.

6.1.2 Sub Research Question Number 2

The second sub research question discusses how the geographical elements information in the spot contract affecting the dynamics of BCTI. In this process, we grouped each individual port in the loading and discharging area as big as 20 regions. We then developed a route for each observation and concluded with 202 route combinations. Out of these 202 routes, we used 14 individual routes that represent 65% of the total contracts. The remaining 35% of the routes are grouped as other in this variable. We also introduced the effect distance in each spot contract to capture the effect of geographical element.

Out of 20 regions, we found three intra trade regions with the most contract in the dataset. Intra West Mediterranean and Caribbean trade are showing favorable condition while the intra AG trade is less favorable. Furthermore, shipments coming out from West Europe is more favorable than the other routes in the dataset, suggesting a premium rate with relatively higher number of contracts.

From this analysis, we can conclude that there is a route segmentation in the handysize CPP market. There are routes that command higher premium rate while several routes are with a premium price. In addition, the findings of geographical model are mainly related with distances between regions. The general findings are short haul which shown in intra-regional trade are associated with lower index that shows discounts. On the other hand, longer haul distances command higher index which shows higher freight rate as well.

6.1.3 Sub Research Question Number 3

The third sub research question discusses the cargo type information in the individual spot contracts data affecting the BCTI. This variable comprised of 13 different cargo types category and one of them is categorized as a generic type which is CPP. The CPP category is used as a reference in the analysis to compare with the other specific cargo type such as aviation oil, naphtha, and the remainder cargo.

The findings indicate that significant result that command higher freight rates are with cargo types of naphtha, light cycle oil, and unleaded motor spirit. This suggests that these types of products are in higher demand compared to the other cargo types. In addition, these cargoes are also shown in major trade routes of BCTI. It has been discussed in the research context that naphtha and unleaded cargo are often shown in several trade routes. This suggests that these cargoes are the main component in the index calculation.

The remainder two variables in this model are the cargo quantity and the cargo utilization which is describe as the ratio of the loaded cargo over the DWT size. These variables show an insignificant result of BCTI. Based on this result, we can conclude that in the handysize CPP segment, the cargo quantity that is transported is irrelevant with the BCTI and also freight rate. From this finding, there is only a little evidence that economies of scale is exist in this specific market size.

6.1.4 Sub Research Question Number 4

The final sub research question in this thesis is the vessel information in the individual spot contracts affecting the dynamics of BCTI. This model is comprised of two variables which are vessel age and DWT. In this model, both variables are showing significance statistical result with different magnitude. The DWT variable is showing a relatively small effect, which indicates that economies of scale is only exist with slight effect in the handysize market. The bigger the vessel size does show a higher rate; however, only with a little effect. The vessel age variable shows that older vessels are associated with higher index and rates. This is reflected that older vessels tend to have higher operating cost; thus, compensated with higher freight rates to cover this expense.

6.2 Research Question Discussion

The proposed research question in this thesis is “What elements of individual tanker spot fixture information affect the Baltic Clean Tanker Index (BCTI) in the handysize tanker market?” It has been discussed in chapter four regarding the data descriptions that the raw data comprised of 16 variables which generally consist of vessel information data and commercial information. Based on these 16 variables, we did not use three variables from the raw dataset which are hull type, charterer name, and ship owner name. The remaining initial 13 variables are developed to obtain additional variables to capture time elements, geographical element, cargo element, and vessel information element. The final dataset that is used is comprised of 13 variables, with nine of them is created. Based on this analysis, we concluded that the time elements, geographical element, cargo element, and vessel information element are affecting the price dynamics of BCTI with the effect and magnitude of these elements have been discussed extensively in chapter five and in each of the conclusion.

6.3 Limitation

This research has shown how we dealt with extensive data and conclude findings. However, there are certain limitations that were faced in this thesis. The first limitation is the data availability and quality which is obtain from SIN. It has been discussed that the available data span is only from 2021 – 2024. We were unable to conclude more robust analysis as the data span is only available for 3.5 years. In addition, we have also showcased that the initial dataset is comprised of 12,363 observations with only 9,416 observations are used. This shows that there is inconsistency in the data compilation by SIN. Other than inconsistency, the data quality raised question mark. We have expressed that there were a lot of missing values in many variables in the dataset. Due to this, we can only remove these inconsistent data to avoid misinterpret the data if manual data correction is done by us.

The second limitation is the inaccurate use of WS platform. The data span from SIN is between 2021 and 2024, while we could only access WS until 2020 as the latest reference. There is a mismatch of the timeframe between these two platforms which could potentially affect the effect of freight rates. Full subscription with substantial fee is needed to access the latest date.

6.4 Recommendation for Future Research

This research is limited in microeconomic approach and only segmented in the handysize market. We show that there are few significant findings in this segment compared with other segment such as in crude oil tankers and the dry bulkers. Similar approach with this thesis can be done with another CPP vessel sizes to justify and compare the results in different tanker segment.

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Appendix I

Table 18. Routes Frequency

Routes	Frequency
Arabian Gulf - Arabian Gulf	289
Arabian Gulf - Australia	3
Arabian Gulf - Caribbean	10
Arabian Gulf - East Africa	359
Arabian Gulf - East Coast North America	3
Arabian Gulf - East Coast South America	20
Arabian Gulf - East Mediterranean	2
Arabian Gulf - Far East	87
Arabian Gulf - Red Sea	59
Arabian Gulf - South Africa	116
Arabian Gulf - Straits	18
Arabian Gulf - UKC	46
Arabian Gulf - West Africa	1
Arabian Gulf - West Asia	55
Arabian Gulf - West Europe	1
Arabian Gulf - West Mediterranean	4
Baltic - Arabian Gulf	1
Baltic - Baltic	15
Baltic - Caribbean	137
Baltic - East Coast North America	2
Baltic - East Coast South America	8
Baltic - East Mediterranean	19
Baltic - Far East	1
Baltic - South Africa	5
Baltic - Straits	1
Baltic - UKC	491
Baltic - West Africa	16
Baltic - West Coast South America	1
Baltic - West Europe	3
Baltic - West Mediterranean	101
Black sea - Arabian Gulf	1
Black sea - Black Sea	6
Black sea - Caribbean	7
Black sea - East Coast North America	2
Black sea - East Coast South America	1
Black sea - East Mediterranean	4
Black sea - UKC	4
Black sea - West Africa	11
Black sea - West Europe	3

Black sea - West Mediterranean	363
Caribbean - Arabian Gulf	1
Caribbean - Caribbean	593
Caribbean - East Africa	25
Caribbean - East Coast North America	38
Caribbean - East Coast South America	178
Caribbean - Far East	27
Caribbean - Red Sea	2
Caribbean - South Africa	6
Caribbean - Straits	2
Caribbean - UKC	222
Caribbean - West Asia	2
Caribbean - West Coast North America	5
Caribbean - West Coast South America	210
Caribbean - West Europe	1
East Coast North America - Baltic	1
East Coast North America - Caribbean	5
East Coast North America - East Coast North America	19
East Coast North America - UKC	3
East Coast North America - West Coast North America	2
East Coast North America - West Coast South America	18
East Coast North America - West Mediterranean	1
East Coast South America - Arabian Gulf	1
East Coast South America - Caribbean	3
East Coast South America - East Coast North America	29
East Coast South America - East Coast South America	1
East Mediterranean - Arabian Gulf	4
East Mediterranean - Baltic	6
East Mediterranean - Black Sea	34
East Mediterranean - Caribbean	135
East Mediterranean - East Africa	33
East Mediterranean - East Coast North America	10
East Mediterranean - East Coast South America	16
East Mediterranean - East Mediterranean	39
East Mediterranean - Far East	6
East Mediterranean - South Africa	27
East Mediterranean - Straits	2
East Mediterranean - UKC	186
East Mediterranean - West Africa	73
East Mediterranean - West Asia	1
East Mediterranean - West Coast North America	1

East Mediterranean - West Europe	3
East Mediterranean - West Mediterranean	1260
Far East - Australia	7
Far East - Far East	14
Far East - Straits	20
Far East - West Coast North America	5
Red Sea - Arabian Gulf	96
Red Sea - Caribbean	7
Red Sea - East Africa	17
Red Sea - East Coast North America	1
Red Sea - East Coast South America	1
Red Sea - East Mediterranean	1
Red Sea - Far East	64
Red Sea - Red Sea	79
Red Sea - South Africa	4
Red Sea - Straits	6
Red Sea - UKC	41
Red Sea - West Africa	5
Red Sea - West Asia	13
Red Sea - West Europe	2
Red Sea - West Mediterranean	1
South Africa - Arabian Gulf	2
South Africa - Caribbean	1
South Africa - East Coast North America	1
Straits - Australia	4
Straits - Far East	6
Straits - Straits	10
Straits - UKC	1
Straits - West Asia	2
UKC - Baltic	1
UKC - Caribbean	80
UKC - East Coast North America	2
UKC - East Coast South America	1
UKC - East Mediterranean	1
UKC - South Africa	5
UKC - UKC	117
UKC - West Africa	18
UKC - West Europe	5
UKC - West Mediterranean	19
West Africa - Caribbean	7
West Africa - East Coast South America	20
West Africa - Far East	1
West Africa - South Africa	4
West Africa - UKC	24
West Africa - West Africa	65

West Africa - West Europe	1
West Africa - West Mediterranean	5
West Asia - Arabian Gulf	48
West Asia - Australia	7
West Asia - Baltic	1
West Asia - Caribbean	1
West Asia - East Africa	144
West Asia - East Coast North America	3
West Asia - East Coast South America	7
West Asia - East Mediterranean	1
West Asia - Far East	84
West Asia - Red Sea	13
West Asia - South Africa	27
West Asia - Straits	38
West Asia - UKC	22
West Asia - West Africa	2
West Asia - West Asia	115
West Asia - West Coast North America	15
West Coast North America - Caribbean	10
West Coast North America - East Africa	4
West Coast North America - East Coast North America	1
West Coast North America - East Coast South America	2
West Coast North America - Far East	3
West Coast North America - West Africa	1
West Coast North America - West Coast South America	9
West Europe - Baltic	20
West Europe - Caribbean	348
West Europe - East Africa	3
West Europe - East Coast North America	31
West Europe - East Coast South America	60
West Europe - East Mediterranean	6
West Europe - Far East	3
West Europe - Red Sea	3
West Europe - South Africa	50
West Europe - Straits	2
West Europe - UKC	464
West Europe - West Africa	130
West Europe - West Coast South America	4
West Europe - West Europe	25
West Europe - West Mediterranean	140
West Mediterranean - Black Sea	4
West Mediterranean - Caribbean	73
West Mediterranean - East Africa	1

West Mediterranean - East Coast North America	2
West Mediterranean - East Coast South America	5
West Mediterranean - East Mediterranean	7
West Mediterranean - Red Sea	1
West Mediterranean - South Africa	4
West Mediterranean - UKC	178
West Mediterranean - West Africa	50
West Mediterranean - West Asia	1
West Mediterranean - West Coast South America	2
West Mediterranean - West Europe	8
West Mediterranean - West Mediterranean	992
Grand Total	**9469**

Source: Derived from the dataset

Appendix II

Table 19. Port References

Regions	Loading Port	Discharging Port
Arabian Gulf	Jubail	Fujairah
Baltic	Brofjorden	Gdansk
Black Sea	Novorossiysk	Constanța
Caribbean	St Johns Antigua	Pozo Colorado
East Africa	Maputo	Port Louis
East Coast North America	Montreal	New York
East Mediterranean	Haifa	Zawia
Far East	Kawasaki	Kaohsiung
Red Sea	Yanbu	Djibouti
South Africa	Durban	Durban
Straits	Singapore	Port Klang
UKC	Fawley, Hampshire	Belfast
West Africa	Lome	Canary Islands
West Asia	Sikka	Colombo
West Coast South America	NA	San Antonio
West Europe	Rotterdam	Sines
West Mediterranean	Cartagena	Genoa
Australia	NA	Kwinana
East Coast South America	Rio de Janeiro	Buenos Aires
West Coast North America	Vancouver	Los Angeles

Notes:

1. There are no shipments coming out from WCSA and Australia
2. Durban is used as a reference for both port; however, there is no intra-regional trade in South Africa

Appendix III

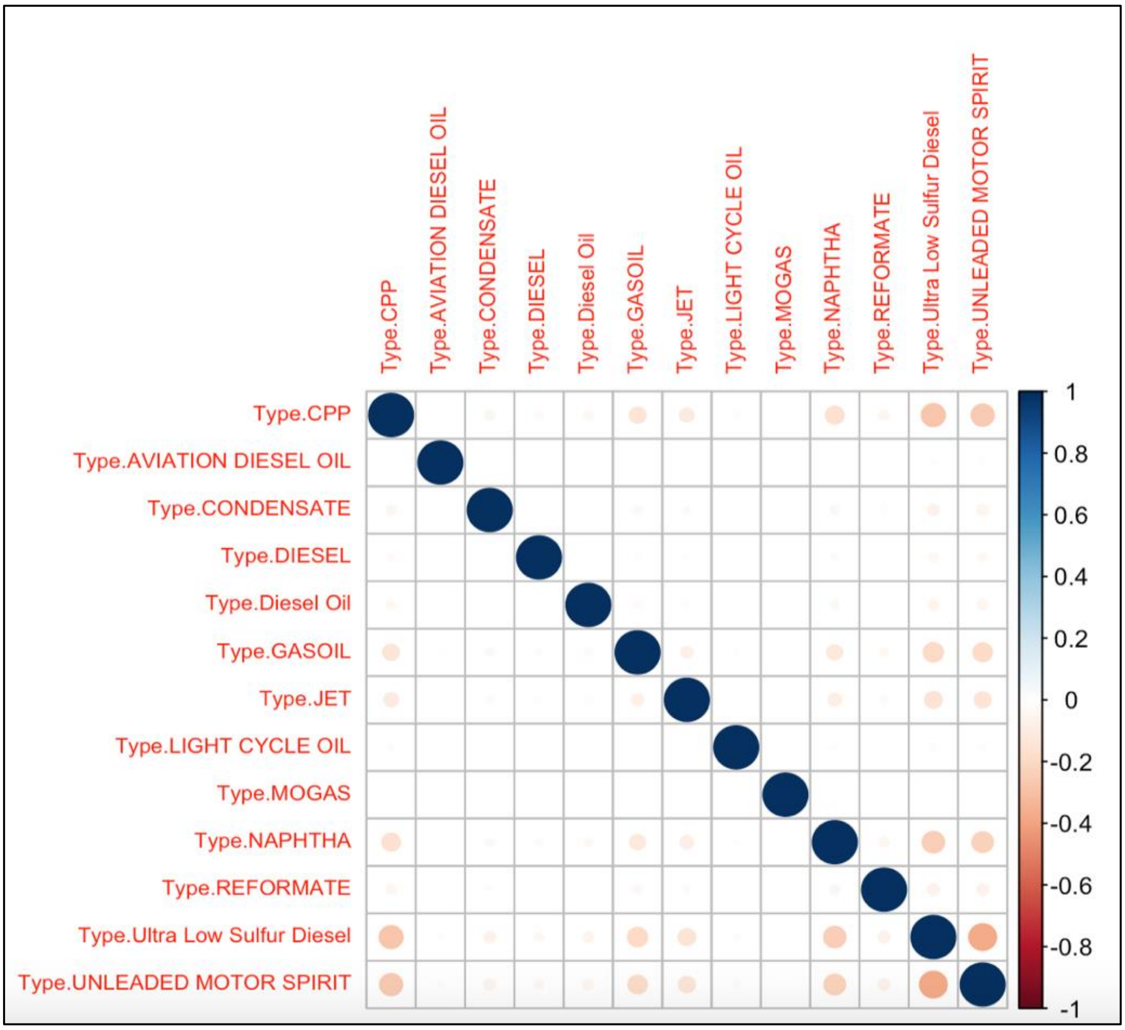

Figure 12. Correlation Plot of Cargo Type

Table 20. Pearson Correlation Testing Result of Cargo Types Variable

Type	CPP	Aviation Diesel Oil	Condensate	Diesel	Diesel Oil	Gasoil	Jet	Light Cycle Oil	Mogas	Naphtha	Reformate	Ultra Low Sulfur Diesel	Unleaded Motor Spirit
CPP	1.0	-0.0077712223	-0.042762815	-0.0265890114	-0.0368508541	-0.133456919	-0.100444799	-0.0118732612	-0.0044862407	-0.164928627	-0.047326845	-0.27622147	-0.256946538
Aviation Diesel Oil	-0.007771222	1.0	-0.001753760	-0.0010904507	-0.0015113026	-0.005473246	-0.004119375	-0.0004869382	-0.0001839867	-0.006763942	-0.001940937	-0.01132821	-0.010537719
Condensate	-0.042762815	-0.0017537599	1.0	-0.0060004387	-0.0083162660	-0.030117707	-0.022667742	-0.0026794819	-0.0010124262	-0.037220042	-0.010680421	-0.06233590	-0.057986058
Diesel	-0.026589011	-0.0010904507	-0.006000439	1.0	-0.0051708778	-0.018726552	-0.014094321	-0.0016660450	-0.0006295052	-0.023142633	-0.006640859	-0.03875914	-0.036054501
Diesel Oil	-0.036850854	-0.0015113026	-0.008316266	-0.0051708778	1.0	-0.025953933	-0.019533926	-0.0023090435	-0.0008724583	-0.032074370	-0.009203852	-0.05371796	-0.049969483
Gasoil	-0.133456919	-0.0054732459	-0.030117707	-0.0187265517	-0.0259539331	1.0	-0.070742935	-0.0083622981	-0.0031596443	-0.116158679	-0.033332139	-0.19454186	-0.180966586
Jet	-0.100444799	-0.0041193749	-0.022667742	-0.0140943214	-0.0195339260	-0.070742935	1.0	-0.0062937864	-0.0023780696	-0.087425480	-0.025087047	-0.14641967	-0.136202397
Light Cycle Oil	-0.011873261	-0.0004869382	-0.002679482	-0.0016660450	-0.0023090435	-0.008362298	-0.006293786	1.0	-0.0002811041	-0.010334289	-0.002965460	-0.01730780	-0.016100054
Mogas	-0.004486241	-0.0001839867	-0.001012426	-0.0006295052	-0.0008724583	-0.003159644	-0.002378070	-0.0002811041	1.0	-0.003904749	-0.001120481	-0.00653965	-0.006083309

Naphtha	-0.164928627	-0.0067639425	-0.037220042	-0.0231426326	-0.0320743695	-0.116158679	-0.087425480	-0.0103342888	-0.0039047492	1.0	-0.041192498	-0.24041857	-0.223641986
Reformate	-0.047326845	-0.0019409369	-0.010680421	-0.0066408592	-0.0092038523	-0.033332139	-0.025087047	-0.0029654602	-0.0011204814	-0.041192498	1.0	-0.06898895	-0.064174848
Ultra Low Sulfur Diesel	-0.276221472	-0.0113282102	-0.062335902	-0.0387591419	-0.0537179611	-0.194541858	-0.146419667	-0.0173078047	-0.0065396505	-0.240418568	-0.068988947	1.0	-0.374554253
Unleaded Motor Spirit	-0.256946538	-0.0105377194	-0.057986058	-0.0360545009	-0.0499694829	-0.180966586	-0.136202397	-0.0161000535	-0.0060833089	-0.223641986	-0.064174848	-0.37455425	1.0

Appendix IV

Table 21. VIF Testing for Cargo Element Model

Variable	GVIF	Df	GVIF^(1/(2*Df))
Rate	1.043744	1	1.021638
Type	1.253094	12	1.009445
Quantity	1.198926	1	1.094955
Cargo Ratio	1.093842	1	1.045869

Table 22. VIF Testing for Geo Element Model

Variable	GVIF	Df	GVIF^(1/(2*Df))
Rate	1.093572	1	1.045740
Route	2.216574	14	1.028835
Distance	2.056805	1	1.434156

Appendix V

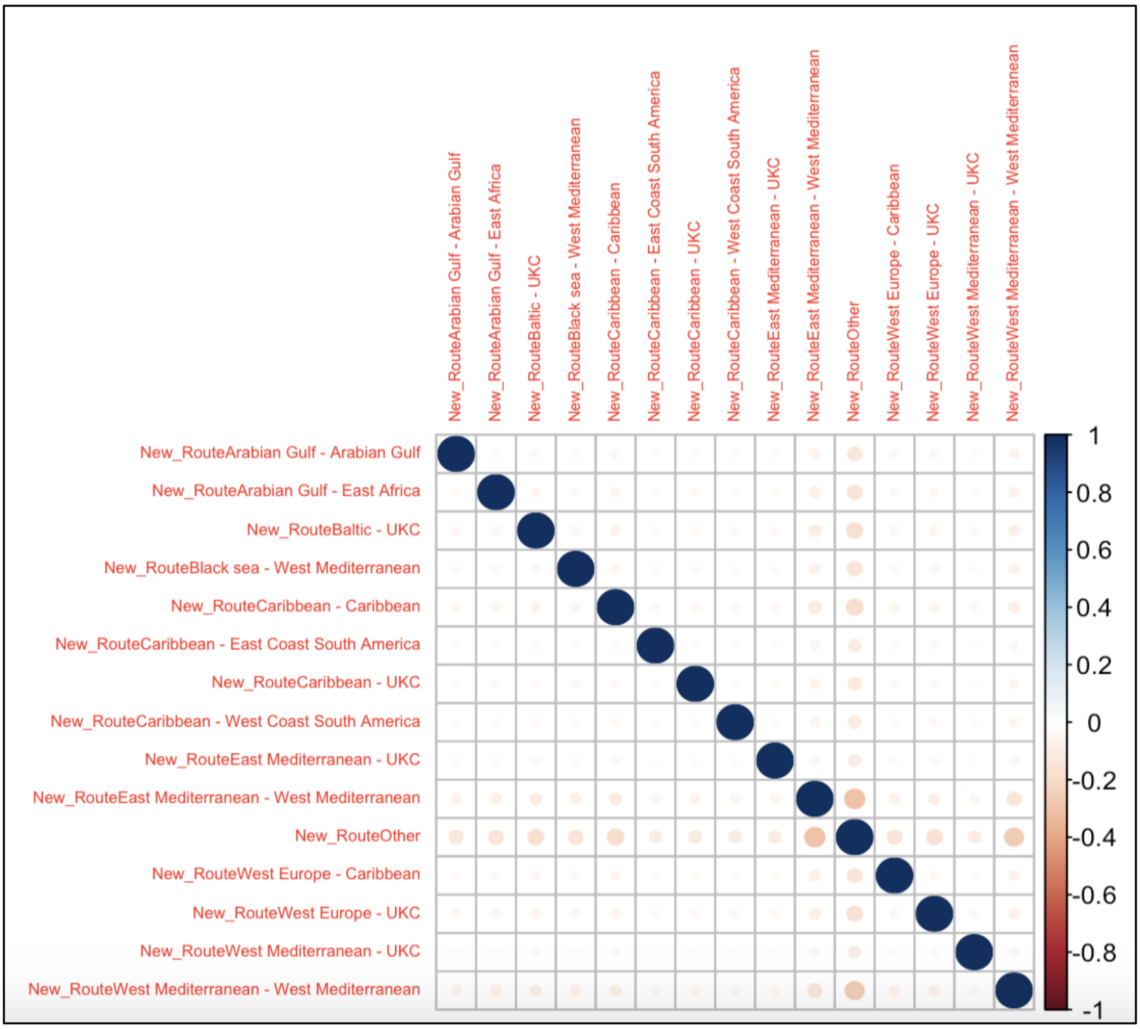

Figure 13. Correlation Plot of Routes

Table 23. Pearson Correlation Testing Result of Routes Variable

Route	AG - AG	AG – EA	Baltic – UKC	BSEA – WM	Carib – Carib	Carib – ECSA	Carib – UKC	Carib – WCSA	EM – UKC	EM – WM	Other	WE – Carib	WE – UKC	WM – UKC	WM – WM
AG - AG	1.0000000	-0.0353129	-0.0416177	-0.0355175	-0.0455922	-0.0245148	-0.0273457	-0.02623365	-0.02514606	-0.06978403	-0.131146	-0.0347450	-0.0403478	-0.0245857	-0.0608513
AG – EA	-0.0353129	1.0000000	-0.0465795	-0.0397520	-0.0510279	-0.0274375	-0.0306060	-0.0293613	-0.0281440	-0.0781039	-0.146782	-0.0388875	-0.0451583	-0.0275169	-0.0681062
Baltic – UKC	-0.0416177	-0.0465795	1.0000000	-0.0468493	-0.0601384	-0.0323362	-0.0360704	-0.0346034	-0.0331689	-0.0920486	-0.172988	-0.0458305	-0.0532208	-0.0324297	-0.0802659
BSEA – WM	-0.0355175	-0.0397520	-0.0468493	1.0000000	-0.0513235	-0.0275965	-0.0307833	-0.0295314	-0.0283071	-0.0785564	-0.147632	-0.0391128	-0.0454199	-0.0276763	-0.0685008
Carib – Carib	-0.0455922	-0.0510279	-0.0601384	-0.0513235	1.0000000	-0.0354244	-0.0395152	-0.0379082	-0.0363366	-0.1008394	-0.189509	-0.0502074	-0.0583035	-0.0355268	-0.0879314
Carib – ECSA	-0.0245148	-0.0274375	-0.0323362	-0.0275965	-0.0354244	1.0000000	-0.0212472	-0.0203831	-0.0195380	-0.0542210	-0.101898	-0.0269963	-0.0313496	-0.0191026	-0.0472804
Carib – UKC	-0.0273457	-0.0306060	-0.0360704	-0.0307833	-0.0395152	-0.0212472	1.0000000	-0.0227369	-0.0217943	-0.0604824	-0.113665	-0.0301138	-0.0349698	-0.0213086	-0.0527403
Carib – WCSA	-0.0262336	-0.0293613	-0.0346034	-0.0295314	-0.0379082	-0.0203831	-0.0227369	1.0000000000	-0.0209079	-0.0580227	-0.109043	-0.0288891	-0.0335477	-0.0204420	-0.0505955

EM – UKC	-0.0251460	-0.0281440	-0.0331689	-0.0283071	-0.0363366	-0.0195380	-0.0217943	-0.0209079	1.0000000	-0.0556172	-0.104522	-0.0276915	-0.0321568	-0.0195945	-0.0484979
EM – WM	-0.0697840	-0.0781039	-0.0920486	-0.0785564	-0.1008394	-0.0542210	-0.0604824	-0.0580227	-0.0556172	1.0000000	-0.290065	-0.0768480	-0.0892401	-0.0543778	-0.1345889
Other	-0.1311465	-0.1467823	-0.1729888	-0.1476327	-0.1895096	-0.1018987	-0.1136658	-0.1090432	-0.1045225	-0.2900656	1.0000000	-0.1444220	-0.1677108	-0.1021933	-0.2529357
WE – Carib	-0.0347450	-0.0388875	-0.0458305	-0.0391128	-0.0502074	-0.0269963	-0.0301138	-0.0288891	-0.0276915	-0.0768480	-0.144422	1.0000000	-0.0444321	-0.0270744	-0.0670110
WE – UKC	-0.0403478	-0.0451583	-0.0532208	-0.0454199	-0.0583035	-0.0313496	-0.0349698	-0.0335477	-0.0321568	-0.0892401	-0.167710	-0.0444321	1.0000000	-0.0314402	-0.0778169
WM – UKC	-0.0245857	-0.0275169	-0.0324297	-0.0276763	-0.0355268	-0.0191026	-0.0213086	-0.0204420	-0.0195945	-0.0543778	-0.102193	-0.0270744	-0.0314402	1.0000000	-0.0474171
WM – WM	-0.0608513	-0.0681062	-0.0802659	-0.0685008	-0.0879314	-0.0472804	-0.0527403	-0.0505955	-0.0484979	-0.1345889	-0.252935	-0.0670110	-0.0778169	-0.0474171	1.0000000