11-3-2019

The lead-lag relationship between vessel traffic and dry bulk freight market

Deni̇z Can Serter

WORLD MARITIME UNIVERSITY
Malmö, Sweden

THE LEAD-LAG RELATIONSHIP BETWEEN VESSEL TRAFFIC AND DRY BULK FREIGHT MARKET

By

DENİZ CAN SERTER
Turkey

A dissertation submitted to the World Maritime University in partial fulfilment of the requirement for the award of the degree of

MASTER OF SCIENCE
In
MARITIME AFFAIRS

(SHIPPING MANAGEMENT AND LOGISTICS)

2019

Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): **Deniz Can Serter.**

(Date): 24.09.2019

Supervised by: Dr. Liping Jiang

Supervisor's affiliation Associate Professor

Acknowledgements

This dissertation would not have been completed if there were no scientific guidance of Dr. Liping Jian. Her directions and inspiring comments were critical for this study.
I would like to thank Mr. Veli Ovacıklı, Director of Turkish Coastal Safety and Prof. Munip Bas, Istanbul Technical University for their valuable contribution on finding the data, historic datasets and vessel traffic information needed for my thesis.
Special thanks to my wife and daughter for supporting me during all my education at World Maritime University.

Abstract

Title of Dissertation: The Lead-Lag Relationship between Vessel Traffic and Dry Bulk Freight Market

Degree: Master of Science

The aim of this paper is to investigate the relationship between the global dry cargo freight rates and the dry cargo vessel traffic in Istanbul Strait. The motivation of this study is based on the neo-classical economic perspective which indicates the supply-demand framework and its outcomes for the shipping business dynamics. In the conventional analysis, it is expected that the rise of freight rates should induce the service productivity and the rise of fleet (in long-run) with a time lag. The rise of vessel traffic may also indicate the increase of supply on existing capacity or productivity (i.e. giving up slow steaming and lay up) basis.

Under these circumstances, this paper considers how these dynamics are interacting through the available dataset. Although it is not the most proper indicator for the entire ship sailings, but as an important shipping route, the vessel traffic volume of Istanbul Strait can be used as a derived outcome of the entire maritime traffic and the mentioned considerations are tested. For the intended analysis, vessel traffic data is eliminated from the seasonal fluctuations (such as usual closures due to the winter conditions) and the remaining data is investigated for a possible causality spillover. The cross-correlations between the intended dataset denoted the existence of lagged associations between the market prices and the vessel traffic volume. The empirical results indicate the leading impact of the time charters rates to the volume of vessel traffic in the strait.

KEYWORDS : Lead lag relationship, dry bulk freights, vessel traffic, Istanbul Strait

Table of Contents

Table of Figures

List of Tables

List of Abbreviations

ADF	Augmented Dickey-Fuller
ARFIMA	Autoregressive Fractional Integrated Moving Average
AIC	Akaike Information Criterion
AIS	Automatic Identification System
ARIMA	Autoregressive Integrated Moving Average
ARCH	Autoregressive Conditional Heteroskedasticity
ARMA	Autoregressive Moving Average
BC	The dwt volume of bulk carrier vessel traffic in Istanbul Strait
BCseasonal or BC (-12)	Seasonal regressor.
BCinstant or BC (-t)	Instant autoregressor.
BCI	Baltic Capesize Index
BDI	Baltic Dry Index
BHMI	Baltic Handymax Index
BPI	Baltic Panamax Index
BSI	Baltic Supramax Index
DOE	Design of Experiments
D.W.	Durbin-Watson statistics.
ECM	Error Correction Model
HF	Time charter rates for Handymax size bulkers (approx. 40k-60k dwt) - USD per day.
J-B	Jacque- Bera
IMO	International Maritime Organization
KPSS	Kwiatkowski–Phillips–Schmidt–Shin
LM	Lagrange multiplier serial correlation test.
PF	Time charter rates for Panamax size bulkers (approx. 60k-80k dwt) - USD per day.
PP	Phillips-Perron

OLS	Ordinary Least Squares estimation.
Q-stat	Ljung-Box Q statistics for residual autocorrelations.
R2	R-squared value.
RMT	Rate of marine traffic
S.E.	Standard error.
SOLAS	The International Convention for the Safety of Life at Sea
VaR	Value at Risk
VECM	Vector Error Correction Model

Chapter 1- Introduction

The role of maritime traffic is frequently discussed from the marine safety perspective and the volume of vessel traffic is a critical debate of the current research agenda (Inoue and Yurtoren, 2004; Aydogdu et al., 2008, 2010, 2012). Beside the safety considerations, marine traffic can be investigated from the economic perspective since the utilization of shipping fleet is depending on the volume of shipments at one part (cargo size is another dimension). The supply-demand framework is composed of the use of shipping fleet and the volume of cargo in the existing theory of maritime economics (Stopford, 2009). The use of shipping fleet refers to the size of fleet and its utilization (i.e. the volume of cargo carried on a navigational distance). However, the measurement of the size of demand and supply is very complicated because of the nature of shipping business. For example, seaborne trade is considered as an indicator of demand while assuming that the demanded shipping service is supplied completely and timely. Otherwise, there is existing gap between the seaborne trade and the real volume of cargo shipment that is offered for the time of estimation.

There may be offers which are not supplied because of fleet limitation in short or medium term shortages. However, these offers are still effective for freight negotiations and fully exist in the market place. In the opposite case, shipping demand is fully supplied while a group of ships are idle and available for bids in market place.

Even no matter whether shipping demand is fully supplied or not, they reflect the demand status and they can still be an indicator for short term fluctuation. Nevertheless, short term fluctuations are believed to be indicated better by assessing lead lag relationship which is the aim of this study.

1.1Background

The recent developments in economic research indicated the role of market players and their perceptions of price rather than the supply-demand framework. A distinct school of behavioral economics is dedicated to deal with the market anomalies and the drawbacks of pure supply-demand framework. There are limited number studies addresses the behavioral aspects of shipping business (Yoshida, 2008; 2009).

An alternative indicator of shipping demand is the frequency and the rate of shipments rather than the size of shipments. May someone argue that these two scales will offer same outcome. However, these scales are slightly different than the traditional one since it deals with an additional dimension which is the rate of marine traffic (RMT) (i.e. the volume of vessel traffic) in a reference point. The theoretical interpretation of the use of the RMT is twofold: First the increasing economic activity and the volume of idle cargo demand strongly motivates the ship managers to be dominant in market place and also to endeavor for increasing the ship's sea speed among other aspects. (Ma, S. 2018) In case of seaborne trade, there is a port-effect which is not taken into account of seaborne volume. The port efficiency is usually out of ship management control and sometimes ships are occupied by the lack of efficient port management (or capacity) and cargo handling equipments. Therefore, the existing tradition is dealing with the nominal size of shipments. The real indicator of the supply side utilization can be derived from the RMT. The second reason of the use of the RMT is the convenience of collecting detailed data even in daily frequencies (e.g. using the data provided by AIS-automatic identification system).

1.2Problem Identification

While successful management of a shipping business depends on the prediction of correct market analysis, the volatility leads to a number of problems.

To be able to identify correct market conditions, lead lag relationship of vessel traffic and freight market can be considered as a good starting point. A simple data set which is available to everyone such as vessel traffic information can be an indicator for freight market of relevant vessel type.

Within this concept, an important particular of the RMT is the selection of the proper reference point such as ports and channels (i.e. straits). Ports are usually dedicated for a limited number of cargoes and size of ships. Therefore, channels are more convenient for the intended purpose. The selected channel should be a unique place for the regional transport link and the intended size group of the fleet. For this paper, Istanbul Strait is selected for empirical work and the statistical significance is tested for the dominant tonnage groups, Handymax and Panamax dry bulk carrier markets. The dry bulk vessel traffic data is selected from the raw data and classified in monthly frequencies while the time charter freight rates of Handymax and Panamax bulk carriers are collected from shipping periodicals (e.g. Astrup Fearnley, Shipping Statistics Yearbook-ISL).

1.3Research Objective

1.3.1 Aim and objective of the study

The aim of this paper is to investigate the relationship between the global dry cargo freight rates and the dry cargo vessel traffic in Istanbul Strait. The motivation of this study is based on the neo-classical economic perspective which indicates the supply-demand framework and its outcomes for the shipping business dynamics. In the conventional analysis, it is expected that the rise of freight rates should induce the service productivity and the rise of fleet (in long-run) with a time lag. The rise of vessel traffic may also indicate the increase of supply on existing capacity or productivity (i.e. giving up slow steaming and lay up) basis. As being only seaway for Black Sea countries such as Russia, Romania, Ukraina; Istanbul Strait comprises 80% of it dry cargo ship traffic from Handysize to Panamax vessel traffic. In this way, relative shipping movement rates are relied upon to be outlined and be related with relevant freight rates with a possible time lag. Displaying such correlations are believed to contribute better shipping resource management.

Under these circumstances, this thesis considers how these dynamics are interacting through the available dataset. Although it is not the most proper indicator for the entire ship sailings, but as an important shipping route, the vessel traffic volume of Istanbul Strait can be used as a derived outcome of the entire maritime traffic and the mentioned considerations are tested. By this way, my proposed study will investigate the lead–lag relationship between vessel traffic in in Istanbul Strait and dry bulk freight market.

In short, objective with this work is to give an insight to the shipowners and shipping investors an indicator for their investments.

1.3.2 Research Question

The problem statement of the thesis is to investigate the expected impact of the marine traffic on dry bulk freight rates at Istanbul Strait to be able to give an insight to the shipowners and shipping investors for their investments. The problem statement is investigated by answering below research questions;

- What are the links between vessel AIS traffic data and freight rates?
- Can a simple data as rate of marine traffic which is retrieved from AIS device on board vessels be an indicator for freight rates?
- How do the vessel traffic data and dry cargo freight rates are interacting through the available dataset at Istanbul Strait for a specified period of time?

To address the objective and primary research question, five research goals are distinguished in this study. These objectives are described with regards to being pertinent for foreseeing freight rates:

1. Concentrate and channel important market explicit vessels from worldwide AIS information. These are Panamax and Handymax bulk carriers.

2. Investigate vessel movements and examples to get market knowledge.

3. Make and distinguish important highlights extricated from AIS information through component investigation techniques.

4. Create relevant models to searching lead lag relationship between freight rates and vessel traffic utilizing multivariate information.

5. Assess the model with customary models utilized in sea freight markets.

1.4Scope of the study and Limitations

The objectives of this study are focused on the interactions between vessel traffic data at the Istanbul Strait, and will not include other ports or straits (such as Singapore Strait, Suez Canal or Panama Canal). Even though there are many other perspectives, this dissertation is limited to the interactions between rate of marine traffic and dry bulk freight rates. Dry bulk vessels are selected for this study as majority of the traffic in Istanbul Strait is dry bulk vessels and dry bulk market is believed to show characteristics of freight rates more accurately. The reason for this is dry bulk market is more liberal in terms of economical and technical implications than compared to tanker and container industry and subject to more fluctuations. A detailed analysis regarding dry bulk market and other shipping markets are explained in Chapter 3.1.1. As a freight market indicator, average time charter contract rates of

Handymax and Panamax bulk carrier tonnage is collected from industry periodicals and compared with seasonally adjusted bulk carrier vessel traffic in Istanbul Strait and the remaining part of the traffic (vessel traffic except bulk carriers). The research is conducted through a quantitative analysis method, using the statistical test procedures.

1.5Dissertation Structure

The thesis is divided into five chapters. Chapter 1 introduces the topic of the lead-lag relationship between vessel traffic and dry bulk freight market while giving insight of the problem addressed through the research. This chapter is used as the basis for the development of the research objective for the scope of the research.

Chapter 2 provides an overview and explanation of the Research Background together with the literature review.

Chapter 3 consists of data introduction and foundation including the design of the research, introduction to the qualitative approach followed and the subsequent analysis tactic applied. Relationship among dry shipping markets and The Baltic Exchange are more analysed together with the AIS data type, to be able to give more insight of the work. This chapter also contains data analysis section that covers the vessel traffic in Istanbul Strait.

In Chapter 4 general methodology is analysed together with sub chapters methodological approach and forecasting horizon.

Chapter 5 contains the key topics involved in the analysis, empirical tests carried to for the answers of the research questions with critical analysis on their expected results.

Chapter 6 is suggesting the recommendations and conclusion of the dissertation while identifying the limitations in the study. Together with the critical recommendations on future works related to the subject, benefits of this study are also provided in this section.

Last Chapter number 7 contains the reference list with bibliography.

Chapter 2 - Research Background and Literature review

From the problem identification as a starting point together with literature review, it turned out to be certain that the utilization of data separated from AIS information to estimate in sea freight rates as maritime economics data is a moderately unexplored field. As far as anyone is concerned, just one examination uses this relationship. AIS information with regards to maritime economics is a generally ongoing improvement, despite the fact that few strategies and applications as of now are investigated; chances to grow the area are available.

The Dry cargo freight rate advertises as a point has scarcely been liable to academic research, thus making open doors for the researchers. The characteristics of dry cargo market is supply driven and what's more, spot directed by the nearness of land value exchange, suggests that looking in to worldwide ship situating and vessel activity may give significant understanding in freight rate estimating.

The spot market is considered to be one of the most volatile markets as in dry bulk shipping, and there exists an impressive vulnerability about the future improvement of these prices.

2.1 Research Background

Istanbul Strait is the sole marine channel for Black Sea-Mediterranean route and the volume of Handysize to Panamax bulk carrier traffic (10,000-80,000 DWT) is over 80% of the entire dry bulk traffic. Therefore, it is expected to illustrate the relative rate of shipping movements and to be correlated with the freight market prices (possibly in a time lag). Modeling such kind of interactions may contribute to the management of facilities, human resources and the existing vessel traffic regime of Istanbul Strait. However, there is a challenging point which lies on the seasonal fluctuations depending on the vessel traffic management. Particularly winter season consists of several canal closures because of the bad weather conditions (dense fog or precipitations). A seasonal adjustment process is utilized to deflate such effects. On the other hand, Istanbul Strait is managed under the one-way regime (North to South or opposite) since August 2005 because of the sub-marine tunnel project, Marmaray, in progress. Although, the decline of vessel traffic volume was concerned by the shipping companies and shippers, the vessel traffic is utilized well and there is no dramatic change on vessel traffic statistics. Even the persistence of one-way regime is an existing debate because of the convenience of vessel traffic management and the marine safety concern. The volume of vessel traffic is growing gradually and no shortage is found at the time of regime switching and later on.

In this paper, the significance of causal relationships between the dry bulk freight market and the volume of dry cargo vessel traffic in Istanbul Strait is investigated.

2.2 Literature Review

This section contains reviewed papers representing the establishment for the work and give a comprehension of the as of now existing strategies and applications inside AIS information. The utilization of satellites receiving AIS data is as yet a generally new idea, so there have been moderately few research utilizing AIS data. A gathering of AIS-related papers have been investigated as a piece of the work done in this thesis. Notwithstanding past work in regards to AIS data, both writing concerning maritime economics matters, the freight market, correlation and lead-lag relationship techniques are among other significant disciplines. This literature review section aims to summarize some past work inside the respective fields to distinguish the state of art within them. A huge part of AIS-related literature is identified with traffic estimation and shipping networks. Kaluza et al. (2010) present an interpretation of the worldwide merchant vessel movements as an intricate network. The general purpose for existing is to comprehend worldwide trade patterns and the impact it has on bioinvasion. Spiliopoulos et al. (2017) present a four-advance methodology on the best way to transform AIS information to data for understanding global trade patterns.

The outcomes can be utilized to monitor changes in shipping trade patterns, which again is associated with global trade patterns. Haji et al. (2013) present the advancement of a model capable of representing container flows at a worldwide level. AIS information is used to distinguish the positions and sizes of container vessels, and this is utilized to appraise container flow. In their work, Arguedas et al. (2014) build up an algorithm to develop maritime transportation lanes from AIS information. The paths are identified by behavioral changes, for example, the Course Over Ground (COG) and port call information. Wu et al. (2017) apply strategies for mapping the worldwide vessel density and traffic density. Vector-based and grid based methods are used for traffic density, and the last has some of the same characteristics from geo-fencing, a technique for extricating information dependent on geographical limits. Another portion of past AIS related writing concerns operational issues, for example, vessel speeds, where Assmann et al. (2015) takes a gander at the connection between vessel speeds under states of high freight rates and low bunker prices. They discover some support for this hypothesis and that speed optimizing behavior is considerably more articulated on ballast trips than on loaded ones. Leonhardsen (2017) investigated through his master thesis the possible fuel savings from quickly re-configurable bulbous bows. A tremendous amount of chronicled speed records from AIS data is investigated. The outcomes are utilized to affirm critical variations in speed during transits and from one voyage to another.

With regards to AIS information quality, Smestad and Rødseth (2015) examines the utility of AIS information, and show the best way to utilize heuristics to set up explicit ship type with sole utilization of AIS information. The reason for anticipating vessel type without extra information is to avoid the cost of obtaining commercial vessel information. Satellite AIS (S-AIS) information is utilized as a premise to make the heuristics, and an information clearing procedure is done to exclude ships that have clashing and inaccurate information. The majority of this past writing is identified with vessel operation, safety, shipping Networks, traffic estimation and environmental issues. There have been generally few studies that have utilized AIS information with regards to maritime economics aspects.

Past work that uses AIS information in maritime economics studies incorporates Adland et al. (2017) who examines the reliability of AIS-based trade volumes. They find that AIS-inferred information for seaborne crude exports show appropriate arrangement with official export numbers in total. As far as concerned, the main study utilizing highlights separated from AIS information to analyze shipping rates is by Olsen and da Fonseca (2017). This thesis examines the predictive capacity of AIS information on account of forecasting Arabian Gulf oil tanker rates. They use the customary Vector Autoregressive (VAR) model in their multivariate conjecture and contrast it with the aftereffects of a univariate estimate. They consolidate the two information removed from AIS and market-explicit information identified with Arabian Gulf oil tanker rates. They locate that multivariate models perform generally superior to univariate models in foresee future freight rates. Definitive, they discover weak proof for utilizing data from AIS-determined information for predictive purposes.

As all shipping commodities, the dry bulk freight rates are determined by the balance among market interest, supply and demand. Thus, each of these is driven by various elements. Subsequently, to get a decent image of this dynamic relationship, it is essential to investigate how these cooperate with one another. The research done by Kavussanos and Nomikos (2003) examines the causal connection between the freight future markets and the spot market in dry cargo bulk shipping. They find that future prices will in general find new data more quickly than spot prices, accordingly using future information may give significant forecasting data notwithstanding highlights separated from AIS information. This study likewise utilizes multivariate determining techniques as they discover proof for utilizing the co-coordinated connection between spot freight rates and forward contracts in forecast spot price.

The study by Batchelor et al. (2007) states that despite the fact that shipping is a non-storable service, implying that the forward price isn't attached to the spot by any arbitrage relationship; they find forward rates to help in anticipating spot prices. In shipping theory, when freight rates are low or the oil price high, the operators diminish sailing speed to reduce operational costs (Ronen, 1982).In the dry bulk shipping market, shipowners will in general speed up when freight rates are high to capitalize on the favorable economic market situations (Tsioumas, 2016).

Concerning estimating in maritime economics aspects, sufficient research has been done in attempting to conjecture crude oil or dry bulk indices, prices and freight rates. Barely any of these studies use AIS information. They basically focus around customs information, shipping indices, and other information. Han et al. (2014) presents an improved Support Vector Machine (SVM) model to forecast dry bulk cargo freight index (BDI). This work looks at determining consequences of three other forecasting techniques and concludes that the proposed method has higher precision in estimating the short term pattern of the BDI. Yu et al. (2008) proposes an empirical mode decomposition (EMD) based neural network to forecast world crude oil spot price. The outcomes from the estimation of West Texas Intermediate (WTI) crude oil spot price show the attractiveness of the proposed method. The study done by Li and Parsons (1997) demonstrates that neural networks altogether beats customary time series models, similar to the Autoregressive Integrated Moving Average (ARIMA) or Autoregressive Conditional Heteroskedasticity (GARCH) models, in estimating oil tanker freight rates.

So hat stays to be investigated apart from these studies? From the literature review, it turned out to be evident that the utilization of data separated from AIS information to forecast in maritime economics is a generally unexplored field. AIS data with regards to maritime economics aspects is a generally late advancement, and the literature review demonstrates that despite the fact that few strategies and applications as of now are investigated; chances to grow the area are available. The market characteristics of the dry bulk, being supplydriven and spot directed by the presence of geographical price arbitrage, implies that looking in to global ship positioning and ship operation may provide valuable insight in forecasting. The spot market is one of the most volatile markets, and there exists a considerable uncertainty about the future improvement of these prices. Outstandingly, also in forecasting multivariate information and nonlinear relationships found in the sea freight markets. Accordingly, the contribution of this dissertation is valuable as it might provide decision support, possibly prompting profitability for the shipowners and operators.

Chapter 3 – Data Introduction

3.1.1 Relationship among dry shipping markets

To be able understand dry bulk markets and their relationship among other shipping markets better, this chapter is introduced. Because of the fact that dry bulk shipping market believed to reflect characteristics and volatility of shipping freight markets more accurately, it is worthwhile to mention about its relationship among dry shipping markets and others. As per introduced in Chapter 1 and literature review sections, the reasoning behind of this fact is the market characteristics of the dry bulk. As a market being supply driven and spot dictated by the presence of geographical price arbitrage, it implies that looking in to global ship positioning and vessel operation may provide valuable insight in forecasting. In addition to that, dry bulk market is more liberal in terms of economical and technical implications than compared to tanker and container industry and subject to more fluctuations.

About the economical point of view of dry shipping markets, they are segmentated as mini bulkers, handmax bulkers, supramax bulkers and capsize vessels in Baltic Exchange according to their freight earnings. Despite of this fact, theses markets not completely segregated from each other (Stopford, 2009). Even though just before the big shipping crisis in 2008, from 2006 to 2007, some ship-owners preferred to convert multipurpose vessels that were basically used for transportation of containers into dry bulk vessels to be able to earn more revenue in healthy demand of dry bulk commodities (Hsiao, Chou, & Wu, 2013). Furthermore, this situation increased the demand for other vessel types such as containers. To this extent, relationship of shipment of cargoes carried on board bulk carriers and container vessels is compared whereas dry bulk vessels transportation is mainly focused on raw materials and container vessels target merchandise. That situation results a lead–lag interaction between these freight markets also.

To explain, in bullish economic situations bulk shipping market will lead in mirroring the progressions of the financial atmosphere. Since the demand in raw material will respond first, because of signs of future higher demands of merchandise as completed or semi-completed items; while market is a downbeat, demand for completed items are right off the bat impacted while raw materials pursued a similar pattern due to decrease in production in the industry.

To be able to illustrate the interactions between shipping markets more, Beenstock and Vergottis (1993a) state that dry bulk shipping market and tanker shipping markets cannot shift far away from one another due to the presence of multipurpose vessels that serves in these markets, as well as new building and scrap activities. Even multi-purpose vessel fleet changed from dry bulk to tanker market while solid transport demand occurred for crude oil or oil products contrast to dry bulk cargoes. Thus, this exchanging situation expands supply in the short turn until ensuing deliveries and development of new shipbuilding activities re-establish the demand-supply balance (Taylor, 2014). As a result of this thinking in line, freight markets of both maritime sectors essentially influence each other in the short-run, which demonstrates an incorporated relationship and volatility transmission between these two freight markets.

3.1.2 The Baltic Exchange

Worldwide dry bulk shipping market plays a pivotal role in the expansion of worldwide economy and trade (Dai, Hu, & Zhang, 2015, p. 353). The previous decade has seen extraordinary fluctuations in dry bulk shipping market, which is reflected by the unexpectedly change in Baltic Dry Index (BDI). The BDI, which was set up on the 1st of November 1999, was determined by obtaining an average of four shipping market freight indices which are the Baltic Cape-size Index (BCI), the Baltic Panamax Index (BPI), the Baltic Supramax Index (BSI) and the Baltic

Handymax Index (BHMI) (the Baltic Exchange, 2016). Afterwards, from the 2nd of January 2007, BDI has been determined as weighted average of four aforementioned standard shipping freight indices (Hsiao, Chou, & Wu, 2013, p. 701).

The Baltic Freight Index (BFI) encountered a few modifications since its introduction to the world, with the expansion of new shipping routes for example a new route from South America to the Far East, while less well known routes were cancelled. Following these change and expanding division in the worldwide dry cargo shipping industry, other related indices were consistently reported after some time by the Baltic Exchange, for example the Baltic Panamax Index (BPI) which is launched in 1998; the Baltic Capesize Index (BCI) launched in 1999; the Baltic Handymax Index (BHMI) made in 2000 and the Baltic Supramax Index (BSI) created in 2005 (Geman & Smith, 2012).

Each business day, a board of worldwide shipbrokers provides freight data on different routes to the Baltic exchange (The Baltic Exchange, 1985). These freight rates assessments are then weighted altogether to ascertain overall BDI and specific indices of different segments like BCI, BPI, BSI, and BHI.

3.2 AIS Data

3.2.1 Introduction

Automatic Identification System (AIS) is a correspondence framework that operates within the maritime Very High Frequency (VHF) system. It comprises of a protocol for correspondence that species the data that will be transmitted, just as the technological equipment that uses this protocol. AIS empower auto exchange of data from the ship. This incorporates static information like navigational details, dynamic information from the vessels sensors, for example speed, and voyage-related data like ships maximum draught, port of destination and Estimated Time of Arrival (ETA). An ordinary utilization of AIS is to exchange data among vessels that are in the similar territory, to keep clear from risky situations. AIS are additionally utilized in management of tracking between a shore station and the ships. AIS information is accumulated by AIS receivers, which can be found on board vessels, buoys and ashore (IALA ,2011).

As of late there have been satellites launched which are gathering AIS information. This information is marked as S-AIS data. The improvement of AIS is a joint undertaking between the International Maritime Organization (IMO) and the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) among others. The work to build up the Automatic Identification System was first started in 1994. Later in 1998, IMO changed guidelines about utilization of AIS to the International Convention for the Safety of Life at Sea (SOLAS) (IMO, 1974).

3.2.2 Message type and content

27 different AIS message types were defined by The International Telecommunication (ITU) (Itu-R, 2014). Table 1 summarizes five most common message types. Some of the information included in message type 1 is presented in Table 2.

As Smestad and Rødseth (2015) argued,AIS message type 1 among others contributes to 72,5 % of all types. Also Table 3 presents AIS message type 5 which is including static vessel info and voyage data.

ID	Name	Description
1	Position report	Scheduled position report
2	Position report	Assigned scheduled position report
3	Position report	Special position report
4	Base station report	Position, UTC, date and current slot number of base station
5	Static and voyage report	Scheduled static and voyage related vessel data report

Table 1: AIS Message types

Information	Description
Unixtime	Number of seconds elapsed since 1 January 1970
Position	Coordinates, longitude and latitude
Speed	Speed over ground (SOG) in knots
Course	Course over ground (COG)
MMSI	MaritimeMobile Service Identity (Vessel ID)
Status	Navigational status

Table 2: Key features in AIS message (type 1)

Information	**Description**
Unixtime	Number of seconds elapsed since 1 January 1970
Vessel specifications	Length and breadth, in meters
Draught	Current draught in meters
IMO Number	InternationalMaritime Organization number
Origin	Origin of current voyage
Destination	Destination of current voyage
ETA	Estimated time of arrival, in Unixtime
MMSI	MaritimeMobile Service Identity (Vessel ID)
Ship Type	Vessel type category

Table 3: AIS message (type 5)

In AIS, system identifies each and every vessel via their MMSI numbers which corresponds to a unique Maritime Mobile Service Identity. This number is connected to the AIS device when first installed on board, and stays until vessel ownership changes. A second unique id number for the system is the IMO number which is engaged to the vessels as the same manner with MMSI. IMO number is given to all vessels of 100 GT or more except of the ones solely engaged in shipping, ships with no mechanical population systems, private, special service vessels, hovercrafts, warships, wooden ships and floating docks

Static AIS message contains vessel’s IMO number whereas MMSI stays as the prime identification number for AIS device. Vessel type is determined as a double-digit number starting from 10 to 99 in AIS. Here first digit shows ship type as shown in below table 4. Second digit of the number gives information about ship’s cargo if ship is carrying marine pollutant, dangerous goods or hazardous cargo on board.

ID	Ship Type
1	Reserved for future use
2	WIG (Wing In Ground)
3	Other vessels
4	High-speed carrier, or vessels < 100 Gross Tonnes
5	Special craft
6	Passenger ships > 100 Gross Tonnes
7	Cargo ships
8	Tankers
9	Other types of ships

Table 4: Vessel types represented by the first digit in AIS

In respect of the interval of the AIS messages, it shows varied frequency with different intervals. Device sends static information and voyage data by 6 minutes intervals or upon each time requested. On the other hand, dynamic data is sent based on vessel's speed and status. Table 5 demonstrates different intervals in respect of data type.

Vessel Operational Status	General reporting interval
Vessel at anchor	3 min
Vessel at 0-14 knots	12 sec
Vessel at 0-14 knots and changing course	4 sec
Vessel at 14-23 knots	6 sec
Vessel at 14-24 knots and changing course	2 sec
Vessel at > 23 knots	3 sec
Vessel at > 23 knots and changing course	2 sec

Table 5: Intervals of dynamic data reporting in AIS

As Skauen et al., 2013 argued, receivers which are land based was collecting the AIS data traditionally are capable of detecting messages around 40-50 nautical miles range from shore. Data for the ships beyond this range cannot be received.

Satellite systems are to be utilized to collect the messages beyond the range. These messages collected with satellites is referred as S-AIS data, are brought together on a global extend. For this purpose, The Norwegian Coastal Guard at present has 4 satellites (Norwegian Space Centre), AISSat-1 (propelled 2011), AISSat-2 (propelled 2014), NorSat-1 (propelled 2017) and NorSat-2 (propelled 2017) gathering information. The mix of information from these satellites is utilized in this venture. For further details, the general guidelines for AIS usage can be found in a document named 'Rules for the on board operational use of shipborne AIS' issued by IMO (2016).

3.2.3 AIS Data Quality

There are a few issues to talk about with regards to the nature of the AIS data quality. Probably the most significant parts of this will be talked about in this part. Further information on AIS data quality is studied broadly by Smestad and Rødseth (2015) and Næss et al. (2017). It is aimed to cover quality issues identified with S-AIS information, general defects of AIS information and some errors of human.

Smestad and Rødseth (2015) figures out that the varieties in traffic gridlock from various timeframes can have expanded inclusion in a region and accordingly the traffic density may look higher. Eriksen et al. (2010) express that over a period length of 24 hours, the High North and South is concealed to multiple times, while the territories around the equator are secured around a few times. With the dispatch of AISSat-2, the range was expanded. The recently propelled NorSat-1 and NorSat-2 will capable the Norwegian Coast Guard to identify 60 % more vessels and gather

2.5-multiple times a bigger number of information than the past utilization of just AISSat-1 and AISSat-2. The satellites can likewise have impedance issues. A satellite will have an a lot bigger inclusion zone than the AIS arrangement of beneficiaries were intended for, so high traffic territories would cause issues. Joined with low circling rates over the region, there could be noteworthy gaps in the information.

There are other potential origins of mistakes than the ones examined with respect to the satellites. These mistakes can either be brought about by a failure in the programmed reports or by errors of human. With respect to previous, Smestad and Rødseth (2015) found that there were a few a great many vessels that had probably some mistaken information. This incorporates, for example, wrong IMO numbers. In any case, this solitary influences the static messages, so the all out number of particular IMO numbers doesn't mirror the all out number of vessels present in the S-AIS information. Leonhardsen (2017) found that the complete number of unique MMSI numbers in the database surpassed the all out number of vessels on the global fleet around then. This might be brought about by vessels changing ownerships over the period for the informational index. Other errors may incorporate wrongly revealed ship measurements and incorrect ship positions. Human errors are also subject to the AIS information. This primarily incorporates physically reported information. The physically reported information incorporate for example the draft, port of destination, estimated time of arrival, course plan and status of the vessel. To delineate these blunders we take a gander at the navigational status of the vessel. The officer of the watch can set the status to 1 or 5 when a vessel isn't proceeding, which means at the anchorage and berthed, respectively. It is the case that responsible officer neglects to change the status while vessel is underway. This can be found in Figure 1, where the information plotted when speed of vessel is over 5 knots and navigational vessel status 1 or 5, for a discretionary arrangement of vessels.

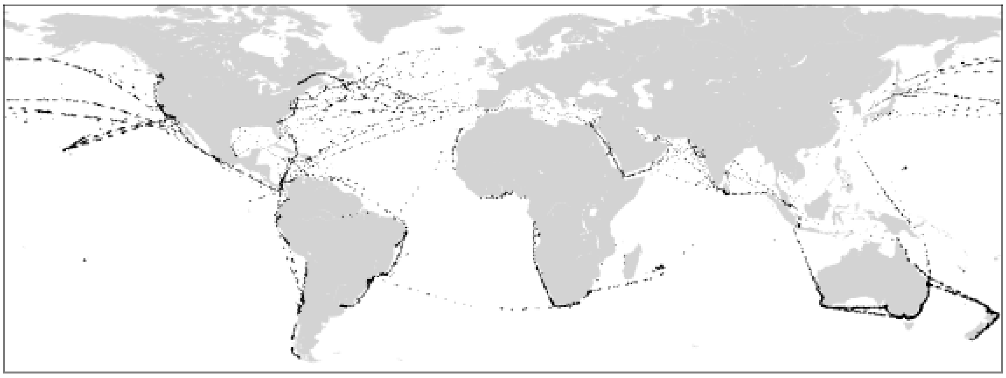

Figure 1 Ships which are proceeding with a speed of 5 knots or above

Chapter 4 –General Methodology and Data Analysis

This study utilizes the data of vessel traffic in Istanbul Strait together with the freight rates associated to dry bulk vessel type and location. Relevant freight data is retrieved as time series from Astrup Fearnley database and vessel traffic information is gained through the database of Turkish Straits Vessel Traffic System. Due to the legal restrictions in Turkish VTS, vessel AIS data in respect of Istanbul Strait had to be restricted between the years 2005 and 2011. So this study is based on this limitation.

In the following part, the general approach of the methodology of this study is presented. Moreover, vessel traffic within Istanbul Strait in respect of Panamax and Handymax vessels are introduced with the forecasting horizon section.

4.1 General Methodological Approach

To go from basic AIS information to predicting lead lag relationship of freight rates, involve some complicated steps. This section aims to show these general steps.

Global raw AIS data of Istanbul Strait was acquired from the Turkish Directorate General of Coastal Safety Authority. To examine the target of this work; in the case of estimating strategies utilizing highlights derived from AIS information includes extra data in anticipating freight rates, we propose the methodology reviewed. The initial step is to unravel the worldwide information. Utilizing an outside AIS parser given by Lane (2006) and a proposed translating technique by Smestad and Rødseth (2015) and Leonhardsen (2017), the AIS information can be decoded and moved to a database. To examine the freight rates of a particular market, a vessel search system should be created to sift through market explicit vessels. Utilizing the AIS data to be presented vessel search procedure, we recognize vessels of intrigue and join the two to a diminished AIS database. This is done with the goal that both computational time and open doors for mistake is diminished. At the point when the information is extricated, and the inquiry limited, we can investigate the information, both ship attributes, and movements, to get a general image of the market and explore examples and potential exploitation. At the point when this is set up, we can make, plan and chose features to be utilized in exploring the lead lag relationship. Choosing which features to develop is a market explicit inquiry, basic the significance of exploratory information analysis. The methodology taken in this study is to create features that are believed to be of interest dependent on past literature and exploratory investigation. With produced AIS-features in addition to market explicit freely accessible information, we can test the significance of the highlights in foreseeing the lead lag relationship dependent on measurable channel methods. These techniques select highlights independently on the model that will accordingly utilize them however are great at pinpointing significant highlights.

4.2 Forecasting Horizon

Shipping cycles is the utmost characteristic of the maritime shipping industry as these cycles emerge because of times with low freight rates, bringing about less development in the maritime sector and expanding the quantity of vessels that are scrapped. As demand increments and more transport are required, the supply can't be balanced quickly, freight rates rise, and development of new vessels begins once more, which in this way creates excessive supply and a bringing down of freight rates. The duration of the cycles is exceptionally capricious and unpredictable, however studies demonstrate that a regular cycle endures around seven years all things considered (Stopford, 2009). As the utilization of S-AIS information to give helpful understanding is a moderately new idea as opposed to the old idea of the shipping industry, in the most pessimistic scenario the information gathered can be inside one of these cycles. In a perfect world, the information gathered ought to mirror an entire shipping cycle to catch the whole market dynamics. Subsequently, as more AIS information is procured and the accumulation reflects longer history, the potential favourable position of utilizing AIS information to foresee freight rates increments.

It is a basic issue to assess the correct horizon for estimating and horizon to separate perceptions. Past studies on sea cargo freight rates fluctuate from day by day to month to month forecasting windows. To utilize AIS-includes in anticipating month to month cargo rates, in a month a vessel may have sailed a long distance. In this way, by examining month to month or quarterly price variances, the quantity of observations would turn out to be low because of the brief timeframe range of AIS information with respect to the historical backdrop of the sea shipping industry. To examine every day variances may likewise be insufficient as the AIS information quality utilized in this investigation have a few holes and mistakes, hence taking a gander at day by day vessel situating may avoid a few vessels for which AIS information was not recorded this particular day. This issue was examined in the underlying phases of the examination by introducing the AIS information to day by day perceptions. These sorts of gaps are regular in the early long periods of S-AIS information before 2013 as the quantity of satellites used to gather information was low notwithstanding information obstruction (Eriksen et al., 2010). Subsequently, estimating day by day variances in cost was not appeared to be fit for this examination. Dry cargo freight rates and commodity prices, as a rule, are extremely volatile in nature (Stopford, 2009). This makes for huge changes in price, henceforth a shorter anticipating window appears to be fit. As needs be, one-advance ahead monthly frequencies are examined in this study. Starting here, to keep up rationality all through the proposal, the time arrangement information inspected are expressed as monthly time steps.

4.3 Data Analysis

4.3.1 Vessel Traffic in Istanbul Strait

The role of Istanbul Strait is very critical for regional ports and particularly for Black Sea- Mediterranean trade. The strait is the sole waterway for cross trading between Black Sea and the rest of world except river trades of Danube. Istanbul Strait is located across the major bulk routes such as crude oil, oil products, iron ore and scrap which return an emphasis from the point of the security of major supplies. Figure 2 illustrates the volume of vessel traffic in the strait and the distribution of vessel type is indicated. Dry Cargo ships (i.e. dry bulk carriers and general cargo ships) are the major part of the entire traffic while oil tankers have the second biggest portion of it. The strong seasonal fluctuations exist in all series.

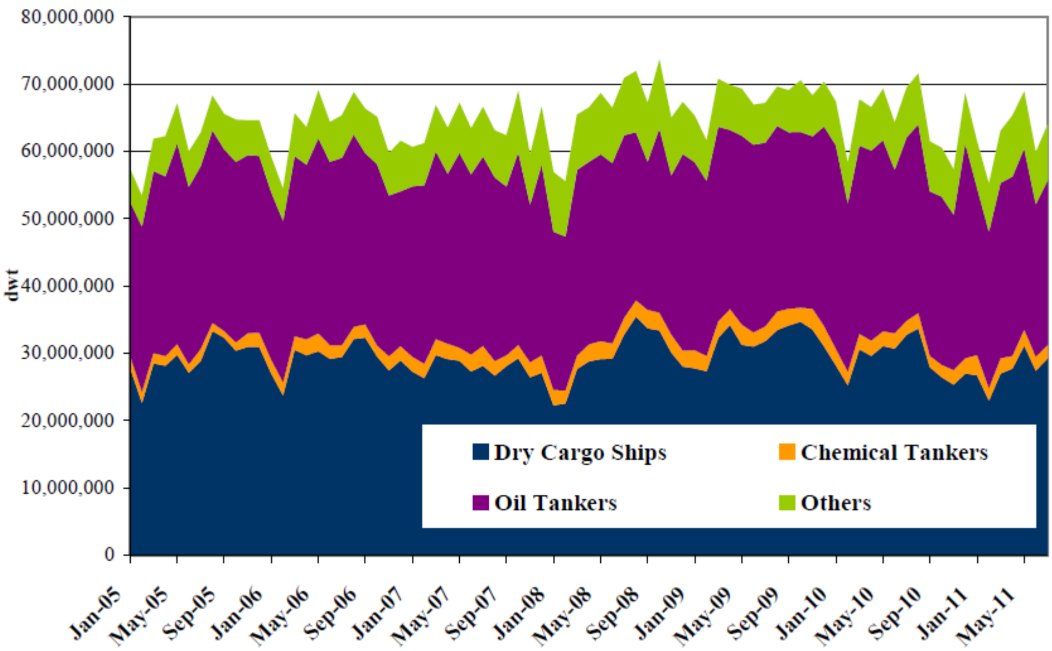

Figure 2. Vessel traffic by the type of ship in Istanbul Strait.

The vessel traffic of Istanbul Strait has significant seasonal fluctuations due to the weather conditions and the daytime changes. The existing traffic management regime regulates the direction of traffic and the special measures for weather conditions (e.g. visibility, current) and the particulars of ships (e.g. large size ships). Ships carrying dangerous goods are also subject to special measures such as daytime transit rule. Although, the average particulars of ships have no unusual changes, weather conditions fluctuate and lead to different vessel traffic characteristics.

Figure 3 indicates vessel traffic data for all ships and dry bulk carriers between January 2005 and July 2011. Due to the AIS data availability, this is the period studied in this dissertation. Seasonal decline exists in winter season and peaks in April-May period. Increasing number of fog, heavy weather conditions and shorter daytimes are major reasons of the seasonal decline. Since the ships carrying dangerous cargo are scheduled for daytime transit, shortage of daytime has particular influence on statistics. The bulk carrier data indicates a declining trend in 2006-2008 periods and climbs up by 2008. The seasonal fluctuations are strongly correlated after 2009.

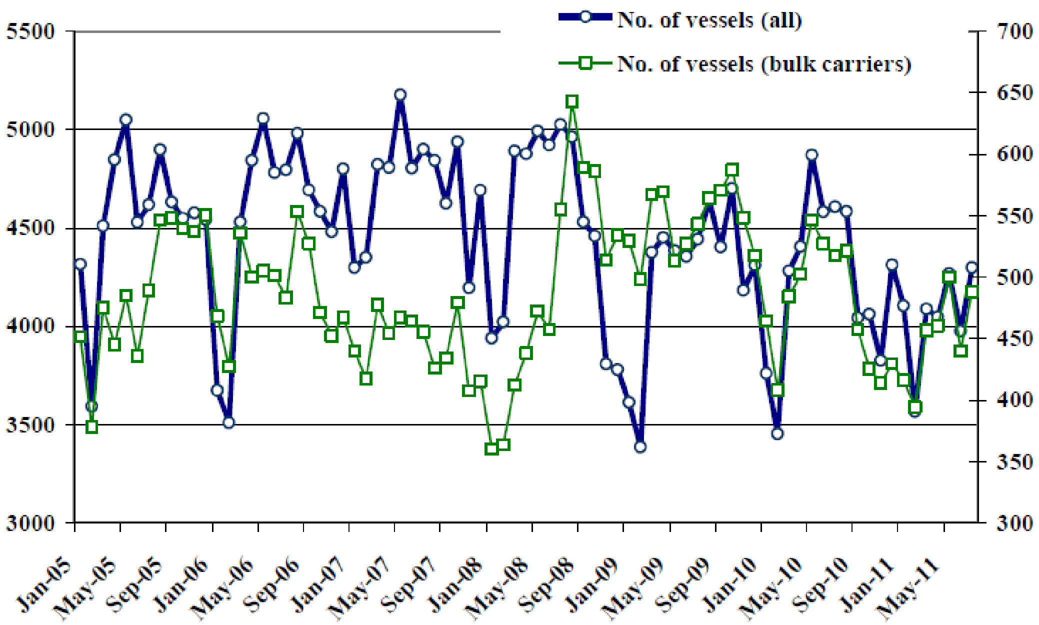

Figure 3. Vessel traffic for all ships (left scale) and bulk carriers (right scale).

The existing strong seasonality prevents to elicit hidden cyclic fluctuation which is based on medium/long term vessel traffic trends. For dealing with this problem, the vessel traffic series are seasonally adjusted by calculating seasonal differences.

The major concern of this paper is to elicit possible linkages between vessel traffic data and freight rates. As a freight market indicator, average time charter contract rates of Handymax and Panamax bulk carrier tonnage is collected from industry periodicals and compared with seasonally adjusted bulk carrier vessel traffic in Istanbul Strait and the remaining part of the traffic (vessel traffic except bulk carriers). Figure 4 shows three time series data (except Panamax series) and both TC rates and bulk carrier traffic indicate a year-peak in a time lag. The remaining vessel traffic is more of a white noise impulses.

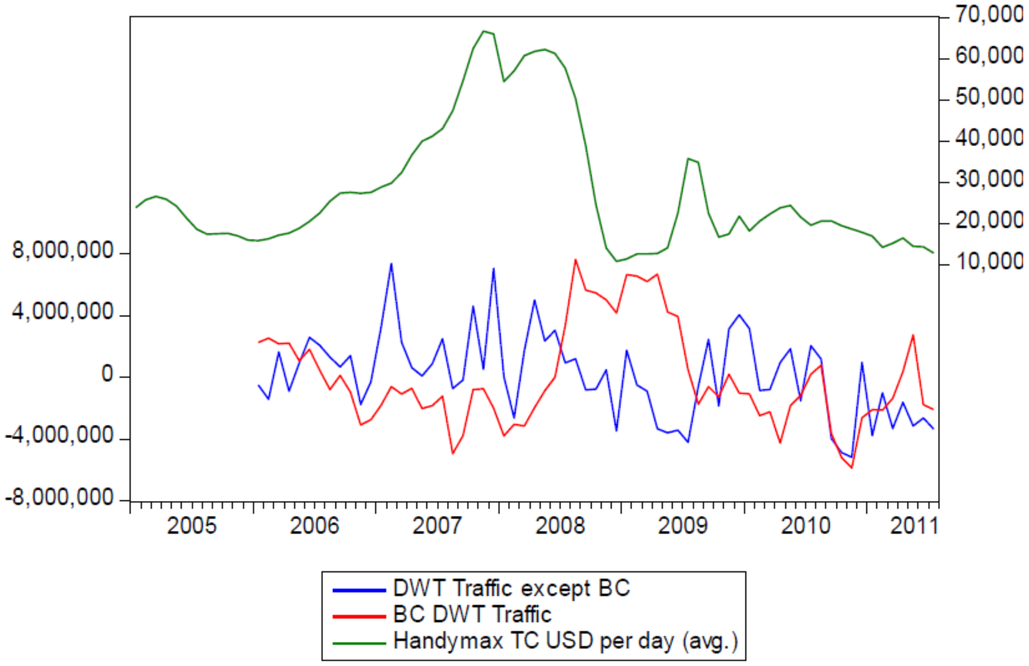

Figure 4. Vessel traffic data (total dwt, left scale) and Handymax TC rates (USD per day, right scale)

For clarifying the existing peak cycle of bulk carrier traffic, the strait closure frequency is compared with the traffic data. Although the closure data does not cover the entire time span (till August 2009), it covers most of the intended period. By August 2005, the underwater tunnel project, Marmaray, has been in operation and the traffic flow is closed for two directions while it is reduced to single direction. In figure 4, both series are compared against possible alternative explanations. It is clear that traffic closures are not the reason for cycles of bulk carrier traffic. Particularly the peak of June 2008-June 2009 does not correlate with the closure data. Therefore, the subsequent assessment is based on the price-traffic spillover approach.

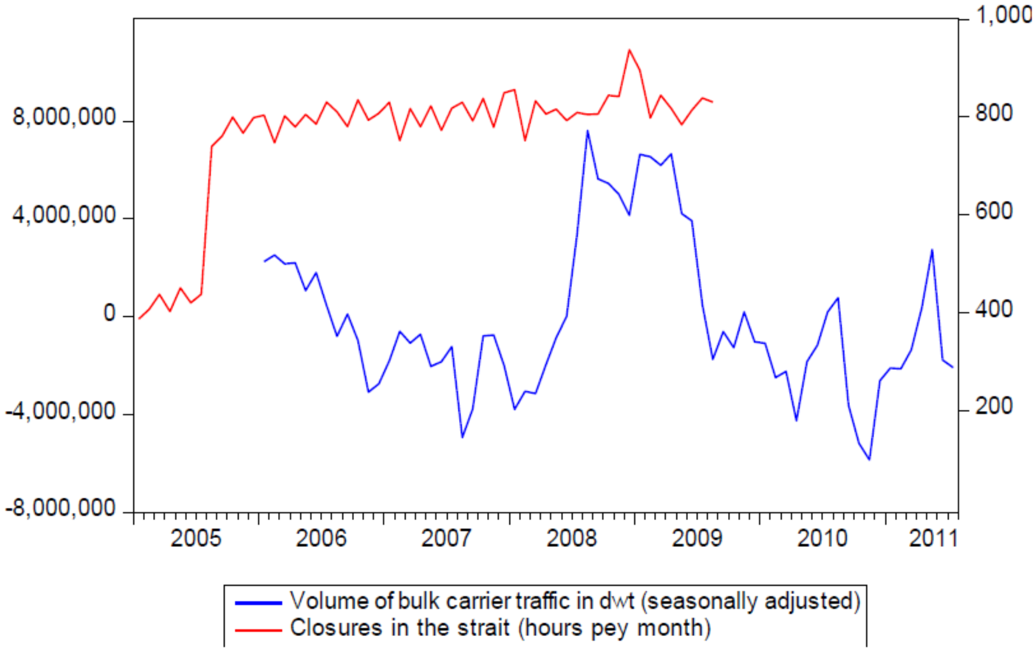

Figure 5. Vessel traffic closures (right scale) and bulk carrier traffic (left scale).

Above mentioned circumstances briefly illustrate the practical correlation between the vessel traffic in Istanbul Strait and the freight rates. The following section analyses the proposed framework by using the statistical test procedures.

Chapter 5 - Empirical analysis and application

The empirical tests are based on the following models:

BC= f (PF, BCseasonal, BCinstant, irregular noise) (eq.1)

and

BC= f (HF, BCseasonal, BCinstant, irregular noise) (eq.2)

where BC is the dwt volume of bulk carrier vessel traffic in Istanbul Strait, PF is time charter rates for Panamax size bulkers (approx. 60k-80k dwt), HF is time charter rates for Handymax size bulkers (approx. 40k-60k dwt), BCseasonal is seasonal regressor (annual time lag in case of monthly series) and BCinstant is the instant autoregressor. The order of BCinstant is based on the correlogram-Q statistics of residuals for the remaining model. For both models, the order of instant regressors is found in the first order autoregression and the empirical results are presented based on these evidences.

The stationarity of proposed variables is tested by using the Ng-Perron (2001) improved testing procedure. Rather than the conventional use, Ng-Perron test is improved for a number of drawbacks exist in Augmented Dickey-Fuller process and Philips-Perron testing procedures. Ng-Perron test calculates four test statistics: MZa (improved Philips-Perron1 test statistics), MZt (based on MZa and MSB), MSB (improved Bhargava2 test statistics) and MPT (improved ADF-GLS). Table 5 presents Ng-Perron test statistics for proposed variables. BC dwt volume series is found significantly stationary and have no unit roots. On the other hand, TC rates have weak form of stationarity based on the low level of confidence.

Exogenous: Constant					
Lag length: 0 (Spectral GLS-detrended AR based on SIC, maxlag=12)					
Sample: January, 2005 – July 2011					
Included observations: 79					
		MZa	MZt	MSB	MPT
BC dwt volume		-14.599*	-2.688*	0.184**	1.728*
Panamax TC rates		-6.640***	-1.750***	0.263***	3.939***
Handymax TC rates		-5.889***	-1.675***	0.284	4.289***
Asymptotic critical values :	1%	-13.800	-2.580	0.174	1.780
	5%	-8.100	-1.980	0.233	3.170
	10%	-5.700	-1.620	0.275	4.450

* Significance at 0.01 level (99% confidence).
** Significance at 0.05 level (95% confidence).
*** Significance at 0.10 level (90% confidence).

Table 5. Ng-Perron unit root-stationarity test results (Ng-Perron, 2001).

Table 6 presents the descriptive statistics for both dependent and independent variables. The degree of volatility is at low levels for all series since the coefficient of variation (CV) is around 0.50 or less. Kurtosis value is less than 3.5 which confirms lack of higher variance.

	BC Volume	Handymax TC Rates	Panamax TC Rates
Mean	16,511,689	27,947	32,069
Median	16,391,187	22,313	24,000
Maximum	21,368,415	66,688	79,625
Minimum	11,077,529	10,888	11,688
Std. Dev.	2,305,713	15,545	20,040
Skewness	0.023	1.233	1.291
Kurtosis	2.444	3.275	3.306
CV	0.14	0.56	0.62
Jarque-Bera	1.023	20.264	22.242
Probability	0.60	0.00	0.00
Observations	79	79	79

Table 6. Descriptive statistics for bulk carrier vessel traffic volume and TC rates.

The order of TC rates is investigated by using cross-correlations. Cross-correlogram of dependent variable, BC, and independent variables, HF and PF, is indicated in Table 7. According to the cross-correlation results, Panamax TC rates lead to bulk carrier traffic in 10 months time lag with highest correlation coefficient (0.73) while the lagging correlations are less than +0.45. For Handymax tonnage, TC rates lead to bulk carrier traffic in 11 months time lag with highest correlation coefficient (0.72) while the lagging correlations are less than +0.40.

Sample: January, 2005 – July 2011
Included observations: 67 months

Panamax TC Rates, BC traffic (-i) Lag	Panamax TC Rates, BC traffic (+i) Lead	Handymax TC Rates, BC traffic (-i) Lag	Handymax TC Rates, BC traffic (+i) Lead	*i*
-0.2214	-0.2214	-0.2644	-0.2644	0
-0.3263	-0.1248	-0.3317	-0.1841	1
-0.4125	-0.0282	-0.3889	-0.0893	2
-0.4387	0.0688	-0.3917	0.0163	3
-0.4338	0.1755	-0.3729	0.1305	4
-0.4119	0.2900	-0.3415	0.2429	5
-0.3836	0.4066	-0.3183	0.3524	6
-0.3432	0.5163	-0.2920	0.4628	7
-0.3054	0.6194	-0.2546	0.5716	8
-0.2870	0.6969	-0.2349	0.6550	9
-0.2723	**0.7302**	-0.2057	0.7094	10
-0.2560	0.7196	-0.1797	**0.7218**	11
-0.2075	0.6856	-0.1504	0.7018	12
-0.1457	0.6494	-0.1250	0.6533	13
-0.0898	0.6133	-0.0976	0.5913	14
-0.0514	0.5705	-0.0758	0.5394	15

Table 7. Lead-lag cross-correlations.

Table 8 presents the empirical results for the Panamax model including a constant term. The standard errors (S.E.) are presented in parenthesis and t statistics are in brackets. The leading influence of Panamax TC rates is estimated for 10 months time lag since the cross-correlations pointed out. According to the S.E.s and t-statistics, explanatory variables have significant contribution at 99% confidence level while the constant term is insignificant. R-squared value is at moderate level of 0.64.

The diagnostic tests for residuals indicated normality (Jarque-Bera test) and white noise (Serial correlation LM test). Correlogram-Q statistics for the second and forth order autoregressions verify that there is no ignored variables rather than the proposed content. The consistency of PF(-10) term is tested against the zero coefficient hypothesis by using the parametric Wald coefficient testing procedure. The test results also confirm the influence of TC rates. An additional test result is presented for joint zero coefficient hypotheses (except constant) and the results significantly reject the zero coefficients for joint hypothesis too.
Although, the goodness of fit (R-sq) is not very high, the existing model indicates that there is a spillover from the dry cargo freight market to vessel traffic volume of the strait. The time lag between the Panamax time charter rates and the vessel traffic volume is found significant at the proposed span of 10 months.

OLS: January 2005-July 2011.

$$BC = -723{,}981.30 + 41.74PF(-10) + 0.30\,BC(-12) + 0.656\,BC(-1) \qquad \text{(eq.1)}$$

(2,081,285)	(12.11)	(0.10)	(0.08)
[-0.348]	[3.447]*	[2.869]*	[8.229]*

R^2: 0.645 S.E.: 1,421,707 D.W.: 1.75 (d_L: 1.50, d_U: 1.69, p: 0.05)
Serial correlation LM test (12 period lags): F-statistics 0.70 (p: 0.73)
Q-$stat_2$: 1.25[3](0.53) Q-$stat_4$: 2.70 (0.61)
Jarque-Bera Normality: 0.18 (0.91)
Wald Test H0: c(2)=0, *t*-value 3.45 (0.001)
Wald Test H0: c(2)=c(3)=c(4)=0, *F*-value 38.16 (0.000)
* Significant at 0.01 level.

Table 8. Model of Panamax bulk carrier vessel traffic volume (dwt).

For the Handymax model, Table 9 presents the empirical results. Similar to the Panamax model, proposed variables are significant except constant term.

Diagnostic tests indicate the validity of model against the lack of residual normality and white noise assumptions.

OLS: January 2005-July 2011.

$$BC = -211{,}740.30 + 55.81HF(-11) + 0.28BC(-12) + 0.629BC(-1) \qquad \text{(eq.2)}$$

(1,922,372)	(14.52)	(0.09)	(0.07)
[-0.110]	[3.843]*	[2.954]*	[7.872]*

R^2: 0.658 S.E.: 1,395,070 D.W.: 1.76 (d_L: 1.50, d_U: 1.69, p: 0.05)
Serial correlation LM test (12 period lags): F-statistics 0.87 (p: 0.57)
Q-$stat_2$: 0.93 (0.33) Q-$stat_4$: 2.47 (0.65)
Jarque-Bera Normality: 0.32 (0.84)
Wald Test H0: c(2)=0, t-value 3.84 (0.000)
Wald Test H0: c(2)=c(3)=c(4)=0, F-value 40.44 (0.000)
* Significant at 0.01 level.

Table 9. Model of Handymax bulk carrier vessel traffic volume (dwt).

The practical meaning of the estimated time lags is considered to be based on regional shipping volume and/or slow steaming or lay-up decisions. Since the freight rate is based on period market prices, there should be a prepositive time lag between contracting and settlement of the deal. Even in the spot market, a prepositive time lag exists between fixtures and Notice-of-Readiness. Shimojo (1979, pp. 230-236) particularly investigated the prepositive time lag effect and indicated significant correlations between freight rates and prepositive terms.

The market pricing and the settlement of the actual shipment usually have a prepositive time lag. Another important factor is the direction of the mainstream routes for major bulk shipments which is mostly carried by bulk carriers over 40k-50k dwt. Relative to other major bulk ports, Black Sea ports are usually importer for major bulk cargoes and these cargoes are probably loaded at distant ports. Although, these indications do not completely clarify the time lag, but may interpret a part of it.

Chapter 6 - Summary and Conclusions

6.1 Research contributions

The contribution of this dissertation can be unfurled from following viewpoints:

Firstly, bearin in mind that shipping is a capital intensive industry; volatility in freight rates causes an abnormal state of threat to the shipping business and thus profitability of the sector. So that, a few players in maritime business and shipping finance markets (shipping investors, shipowners, financial players, charterers, regulatory bodies etc.) can get a better picture and understanding of return the lead lag relationship among dry bulk markets and vessel traffic.

Along these lines, it would place them in healthy decision making process, help to improve their portfolio diversification, hedging freight risks.

Furthermore, the connections among vessel traffic information and freight rates can give a compelling risk management instrument, which can improve the basic decision making and leadership process among shipping players. It may further help to builds effectiveness in cost estimation in shipping freight derivatives.

Thirdly, there is clear proof during crisis periods that the volatility extends unequivocally and overflows to another market which exhibits co-developments of business sectors (Reinhart and Rogoff, 2008). In this way, exploring and estimating freight rates together with the AIS Data which can be a pointer for volatility can characterize early indications of shipping freight market crisis and the successful use of hedging strategies by financial specialists and regulatory bodies.

Fourthly, shipping freight rate accept a genuine piece of cash stream producing ability of maritime organizations, charterers, investors and financial bodies. It stems the way that shipping freight markets are exposed to volatility alongside various other particular features. Maritime shipping freight rates fundamentally influence the worldwide capital markets and outfit a compelling worldwide financial activity pointer (Alizadeh and Muradoglu, 2014). In this way, it is significant for all players in the shipping business and financial markets to investigate relationship of various factors on freight rates over shipping freight markets.

6.2 Concluding Remarks

Together with this dissertation, it is aimed to investigate the lead lag relationship between vessel traffic information extracted from Automatic Identification System (AIS) data in Istanbul Strait and dry bulk freight rates. This concept adds additional information in predicting the lead lag relationship between freight rates and vessel traffic and Istanbul Strait is used as a case study for this purpose.

While maritime traffic has a particular importance in terms of maritime safety, it also tells about the current volume of shipping business practice. On the other hand, the shipping deals and contracts may indicate the volume of vessel traffic in the immediate future. The practical meaning of a priori information about the vessel traffic volume is based on the efficient use of existing systems (e.g. tugs, operators, watchkeeping schedule) which contributes to the enterprise resource management (ERM) and also the traffic management regime (e.g. bi-directional vs. unidirectional orientation).

This paper investigated the significance of the proposed hypothesis for Istanbul Strait and presented a number of econometric models for further improvements and practical use. The proposed framework significantly indicated that the seasonally adjusted volume of vessel traffic in Istanbul Strait has a causality link with the most related freight market and the time charter rates of Handymax and Panamax size bulkers pointed out a prospective leading impact to the volume of vessel traffic in variety of time lags (10-11 months). The interpretation of the existing time lags is partially accounted for the theory of prepositive time by means of Shimojo (1979). On the other hand, we keep the limitations of statistical causality in mind and also refer to alternative expressions such as the productivity changes (i.e. slow steaming, lay-ups) or misleading outcomes from a limited dataset which is an essential fact for statistical inference.

Overall, the results from our final analysis establish evidence in favor of using features extracted from freight rates has shown as lead indicator for marine traffic within Istanbul Strait.

Even though the model results show the lead lag relationship, it is acknowledged that there are many limitations to my research, especially concerning the quality and the quantity of the AIS data when it was available from the source. The quality of the AIS data varies due to interference errors and early stage gaps of the satellite coverage. This fact should be considered before using AIS data for further studies. Similarly, when more AIS data is gained representing longer history, the potential advantage and accuracy of the intended study will increase.

6.3 Recommendations for future work

Further research about the utilization of AIS Data in the context of shipping economics is ecncouraged. Together with the findings in this dissertation and the moderately unexplored field of combination of AIS information and freight rates, there is potential in taking advantage of the data fused in AIS-messages. With the various data in both static and dynamic messages, more sophisticated features can be made. As more AIS information is procured and the gathering reflects longer history with higher quality information, components like draft and course data can be utilized.

It is additionally recognized that with the extent of this study being wide, further advancement of each progression in the methodology can improve model execution. It is at last suggested that, after surveying the methodology, whether this study can be applied to other shipping industries. Choosing which features to build is a market explicit inquiry, and comprehension of the market dynamics is similarly as significant as developing complex models.

Chapter 7 - References

Adland, R., Jia, H., and Strandenes, S. P. (2017). Are AIS-based trade volume estimates reliable- The case of crude oil exports. Maritime Policy and Management.

Alizadeh, A. H., & Muradoglu, G. (2014). International Financial Markets, Institutions and Money Jornal, Stock market efficiency and international shipping-market information.

Arguedas, V. F., Pallotta, G., and Vespe, M. (2014). Auto generation of geographical networks for maritime traffic surveillance - Semantic Scholar. 17th International Conference on Information Fusion (FUSION), pages 1–8.

Assmann, L., Andersson, J., and Eskeland, G. S. (2015). Speed optimization and slow steaming in maritime shipping.

Aydogdu, V., Park, J-S., Keceli, Y., Park, Y-S. (2008). Analysis of Marine Traffic Features for Safety Assessment at southern Entrance of the Istanbul Strait-I. Journal of Korean Institute of Navigation and Port Research, 32, 521-527.

Batchelor, R., Alizadeh, A., and Visvikis, I. (2007). Forecasting spot and forward prices in the international freight market. International Journal of Forecasting.

Bhargava, A. (1986). On the theory of testing for unit roots in observed time series, Review of Economic Studies, Vol. 53, pp. 369-384.

Brooks, C. (2014). Introductory econometrics for finance (3rd ed.). Cambridge: Cambridge University Press. Dickey, D.A. and Fuller, W.A. (1979). Distribution of the estimators for autoregressive time series with a unit root, Journal of the American Statistical Association, Vol. 74

Dai, L., Hu, H., & Zhang, D. (2015). An empirical analysis of freight rate and vessel price volatility transmission in global dry bulk shipping market. Journal of Traffic and Transportation Engineering

Dickey, D. A., & Fuller, W. A. (1981). Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. Econometrica, 49(4), 1057-1072. doi: 10.2307/1912517

Duru, O. (2012). Incentives and sentiments in shipping investments: Intermediary prospects between the impatient capital and long-term competitiveness. Journal of Logistics and Shipping Economics, Vol. 45, 63-72.

Bulut E. and Yoshida, S. (2012b). A fuzzy extended DELPHI method for adjustment of statistical time series prediction: An empirical study on dry bulk freight market case. Expert Systems with Applications, Vol. 39(1), 840-848.

Eriksen, T., Skauen, A. N., Narheim, B., Helleren, O., Olsen, O., and Olsen, R. B. (2010). Tracking ship traffic with Space-Based AIS

Eviews (2019, July). EViews Help. Retrieved August, 2019, from http://www.eviews.com/help/helpintro.html

Geman, H., & Smith, W. O. (2012). An analysis of the Shipping markets and freight rates, Baltic Dry Index. Alternative Investment Jornal

Haji, S., O'Keeffe, E., and Smith, T. (2013). Global container shipping network estimation using data and models. 2013.

Han, Q., Yan, B., Ning, G., and Yu, B. (2014). Forecasting Dry Bulk Freight Index with Improved SVM. Mathematical Problems in Engineering, 2014:1–12.

Hsiao, Y., Chou, H., & Wu, C. (2013). Return lead–lag and volatility transmission in shipping freight markets. Maritime Policy & Management

Inoue, K., Yurtoren, C. (2004) The Risk and Control of Marine Traffic Accidents within Istanbul Strait. Institute of Navigation Japan Journal, 110, 19-26.

IALA (2011). Report of the workshop on the global sharing of maritime data

IMO (2017). Automatic identification systems (ais). http://www.imo.org/en/OurWork/safety/navigation/pages/ais.aspx Retrieved 27 July 2019.

International Trade Statistics 2013. (2014). World Trade Organisation. Retrieved August, 2014, from http://www.wto.org/english/res_e/statis_e/its2013_e/its2013_e.pdf

Itu-R (2014). Technical characteristics for AIS, Mobile, radio determination, amateur and related satellite services

Jarque, C. M., & Bera, A. K. (1980). Efficient tests for normality, homoscedasticity and serial independence of regression residuals. Economics Letters, 6(3), 255-259. doi: 10.1016/0165-1765(80)90024-5

Johansen, S. (1988). Statistical analysis of cointegration vectors. Journal of Economic Dynamics and Control, 12(2-3), 231-254

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. Econometrica, 59(6), 1551

Jugovic, A., Komadina, N., & Hadzic, A. P. (2015). Factors Influencing the Formation of Freight Rates on Maritime Shipping Markets. Multidisciplinary Scientific Journal of Maritime Research.

Kaluza, P., Kölzsch, A., Gastner, M. T., and Blasius, B. (2010). Cargo ship movements complex network Royal Society Journal, Interface, 7(48):1093–103.

Kavussanos, M. G., & Alizadeh-M, A. H. (2002). Seasonality patterns in tanker spot freight rate markets. Economic Modelling, 19(5), 747-782.

Kavussanos, M. G. (2003). Time Varying Risks Among Segments of the Tanker Freight Markets. Marit Econ Logist Maritime Economics & Logistics, 5(3), 227-250.

Kavussanos, M. G., Visvikis, I. D., & Dimitrakopoulos, D. N. (2014). Economic spillovers between related derivatives markets: The case of commodity and freight markets. Transportation Research Part E: Logistics and Transportation Review, 68, 79-102.

Kwiatkowski, D., Phillips, P. C., Schmidt, P., & Shin, Y. (1992). Testing the null hypothesis of stationarity against the alternative of a unit root. Journal of Econometrics, 54(1-3), 159-178. doi: 10.1016/0304-4076(92)90104-Y

Leonhardsen, J. H. (2017). Estimation of Fuel Savings from Rapidly Reconfigurable Bulbous Bows Exemplifying the Value of Agility in Marine Systems Design

Li, J. and Parsons, M. G. (1997). Forecasting tanker freight rate using neural networks. Maritime Policy & Management, 24(1):9–30.

Ma, S. (2018). Maritime Economics. Malmo: World Maritime University

Ng and Perron, 2001. Lag length selection and the construction of unit root tests with good size and power, Econometrica, Vol. 69, pp. 1519–1554.

Næss, P. A., Grundt, E. H., and Axelsen, J. J. (2017). Exploration of Methods for Analysing AIS Data.

Olsen, M. and da Fonseca, T. R. K. (2017). Investigating the Predictive Ability of AIS-data: The case of Arabian Gulf tanker rates.

Phillips P.C.B. and Perron P., (1988). Testing for a unit root in time series regression, Biometrika, Vol. 75, pp. 335-346.

Reinhart, C., & Rogoff, K. (2008). Is the 2007 A Historical Comparison of U.S. Sub-Prime Financial Crisis- Is it so Different?

Ronen, D. (1982). The Effect of Oil Price on the Optimal Speed of Ships. Journal of the Operational Research Society, 33(11):1035–1040.

Shimojo, T. (1979). Economic Analysis of Shipping Freights, Kobe University Press, Kobe, Japan.

Smestad, B. B. and Rødseth, J. (2015). A Study of Satellite AIS Data and the Global Ship Traffic Throughthe Singapore Strait.

Spiliopoulos, G., Zissis, D., and Chatzikokolakis, K. (2017). Extracting, a Big Data Driven Approach Global Trade Patterns. pages 109–121.

Stopford, M. (2009). Maritime economics (3rd ed.). London: Routledge

Taylor, M. P. (2014). The applied economics of transport. London: Routledge.

The Baltic Exchange. (2019) Retrieved from website: www.balticexchange.com

Tsioumas, V. (2016). Quantitative analysis of the dry bulk freight market, including forecasting and decision making. PhD thesis, Department ofMaritime Studies University of Piraeus.

UNCTAD. (2018). Review of maritime transport. Microform & Digitization Review, 41(1). Retrieved from http://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

Visvikis, I. D. (2002). An econometric analysis of the forward freight market. London: City University.

Wu, L., Xu, Y., Wang, Q., Wang, F., and Xu, Z. (2017). AIS Data to Mapping Global Shipping Density. Navigation Journal, 70(01):67–81.

Yoshida, S. (2008). Market psychology, Lloyd's Shipping Economist, August.

Yoshida, S. (2009). Judgmental forecasting in the dry bulk shipping business: Statistical vs. judgmental approach. Asian Journal of Shipping & Logistics, Vol. 25(2), 189-217.

Yoshida, S. (2010). Seasonality patterns in dry cargo vessel traffic of the Strait of Istanbul and interactions with freight rates.

Yu, L., Wang, S., and Lai, K. K. (2008). Forecasting crude oil price with an EMD-based neural network ensemble learning paradigm. Energy Economics, 30(5):2623–2635.