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A study on the reasons for sharp decline on the Baltic exchange dry index in 2008

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A STUDY ON THE REASONS FOR SHARP DECLINE ON THE BALTIC EXCHANGE DRY INDEX IN 2008

By

SUNG MAN JUNG
Republic of Korea

A dissertation submitted to the World Maritime University in partial Fulfilment of the requirements for the award of the degree of

MASTER OF SCIENCE

In

MARITIME AFFAIRS
(PORT MANAGEMENT)

2015

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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.

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ABSTRACT

Title of Dissertation: **A Study on the reasons for sharp decline on the Baltic Exchange Dry Index in 2008**

Degree: MSc

This dissertation starts from the decline of the Baltic Dry Index (BDI) of the Baltic Exchange in 2008 from 11,793 point to 663 point, which decreased by 94% from the peak within 7 months. To detect the reasons for the sharp decline of BDI, this dissertation has focused on the direction of research into demand and supply on shipping industry.

All variables related with demand on shipping are divided into two groups - sea borne trade volume variables and the physical commodity price variables, ship dead weight tonnage (DWT) was selected as a supply variable, and Net Futures Position and Open-Interest were selected as financial market variables.

On one hand, this dissertation tried to find the reasons for the collapse of BDI through the comparison of explainable power on the estimated model obtained by the empirical tests. Furthermore, in order to find the reasons for the sharp decline of BDI in 2008, this dissertation investigated correlation and causality between BDI and Seaborne trade volume, BDI and commodity price, and commodity price and financial market through the correlation test and regression analysis by empirical test.

To sum up, the results of empirical test and the findings so far, this dissertation found that at least the reasons for the sharp decline in BDI did not caused by seaborne trade volume. Secondly, the increase of supply ship commitment was one of the main reasons for the collapse of BDI in line with the nature of demand and supply curves of freight market. And finally, further discussions on causality between physical-based commodity price and futures market need to be conducted by further research, due mainly to the “financialization”, which means that the role of futures market against physical-based commodity price has increased over the time of crisis.

**KEY WORDS:** Commodity Price, Baltic Exchange Dry Index(BDI), Financialization, Futures, Sea borne Trade, Financial, Crisis, Correlation, Causality, Regression, Shipping, Tramp, Derivative, Commodity, Maritime Economics.
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List of Abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>ARIMA</td>
<td>Auto Regression Integrated Mathematical Analysis</td>
</tr>
<tr>
<td>BCI</td>
<td>Baltic Exchange Capesize dry bulk shipping Index</td>
</tr>
<tr>
<td>BDI</td>
<td>The Baltic Exchange Dry Index</td>
</tr>
<tr>
<td>BHSI</td>
<td>Baltic Exchange Handy Size Index</td>
</tr>
<tr>
<td>BIS</td>
<td>Bank for International Settlements</td>
</tr>
<tr>
<td>BPI</td>
<td>Baltic Exchange Panamax Index</td>
</tr>
<tr>
<td>BSI</td>
<td>Baltic Exchange Supramax Index</td>
</tr>
<tr>
<td>C</td>
<td>Constant</td>
</tr>
<tr>
<td>CFTC</td>
<td>Commodity Futures Trading Commission</td>
</tr>
<tr>
<td>CLRM</td>
<td>Classical Linear Regression Model</td>
</tr>
<tr>
<td>Cov</td>
<td>Covariance</td>
</tr>
<tr>
<td>Cr</td>
<td>Critical</td>
</tr>
<tr>
<td>DNV</td>
<td>Det Norske Veritas</td>
</tr>
<tr>
<td>DWT</td>
<td>Dead Weight Tonnage</td>
</tr>
<tr>
<td>EGARCH</td>
<td>Exponential Generalized Autoregressive Conditional Heteroscedasticity</td>
</tr>
<tr>
<td>FFA</td>
<td>Forward Freight Agreement</td>
</tr>
<tr>
<td>GARCH</td>
<td>Generalized AutoRegressive Conditional Heteroskedasticity</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>ICS</td>
<td>International Chamber of Shipping</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>JODI</td>
<td>Joint Organizations Data Initiative</td>
</tr>
<tr>
<td>LNG</td>
<td>Liquefied Natural Gas</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>Description</td>
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<tr>
<td>--------------</td>
<td>-------------</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
</tr>
<tr>
<td>OECD</td>
<td>Organization for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PANAMAX</td>
<td>Panama Canal Maximum</td>
</tr>
<tr>
<td>Prob</td>
<td>Probability</td>
</tr>
<tr>
<td>Std</td>
<td>Standard</td>
</tr>
<tr>
<td>TCavg</td>
<td>Time Charter average</td>
</tr>
<tr>
<td>UNCTAD</td>
<td>United Nations Conference on Trade and Development</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>United States of America</td>
</tr>
<tr>
<td>VAR</td>
<td>Vector Auto Regression</td>
</tr>
<tr>
<td>VECM</td>
<td>Vector Error Correction Model</td>
</tr>
<tr>
<td>WTI</td>
<td>West Texas Intermediate</td>
</tr>
</tbody>
</table>
1. Introduction

In order to progress with this dissertation to find reasons for the collapse of BDI in 2008, this chapter addresses what the motive and the objectives are; as well as the methodology on how to progress with the dissertation. In addition, the overall organization and limitations of this dissertation will be dealt with.

1.1. Background

The Baltic Exchange Dry Index (BDI), the successor to the Baltic Freight Index (BFI), came into operation on 1 November 1999.

Figure 1: The trend of BDI from 1985 to 2012
(Source: http://www.bloomberg.com/markets)
It is used by the people working in the shipping industry and economic analysts as a benchmark of economic activity in shipping and as a tool for forecasting the market fluctuations (Baltic Exchange, 2013). At least until the financial crisis in 2008, it was regarded as a barometer of the shipping market as well as a leading indicator of global economy because people working in the shipping industry believed that it can reflect demand and supply of the raw material market.

The financial crisis in 2008 had a great impact on the global based physical market as well as the shipping industry. For instance, in the aftermath of the financial crisis in 2008, the BDI has sharply decreased by 94%, from 11,793 points to 663 points within 7 months. However, seaborne trade volume of 2009 decreased by only 5.5% in the same period (UNCTAD, 2013).

Despite the fact that there is a huge difference between the change of physical seaborne trade volume and the change of BDI, the Baltic Exchange, which publishes the BDI daily, still insisted that BDI reflected market conditions as shown below:

“Our indices and assessments are used as a settlement tool for freight derivative trades, for benchmarking physical contracts and as a general indicator of the bulk market's performance”(www.balticexchange.com).

1.2. Objective

According to the Cross Market Linkage effect proved by previous researchers, four main markets affecting the change of Freight Rate (BDI) are related to each other. Paying attention to the cross market linkage as shown below, this dissertation focused on finding the reasons for the collapse of BDI in 2008 through the study on the relation between the physical market and BDI, and the relation between physical market and the derivative market.
To achieve the objective, this dissertation set up three hypotheses as follows:

① Is there a statistically significant correlation between BDI and the physical-based sea borne trade volume?

② Is there a statistically significant correlation between BDI and the physical-based commodity market price?

③ Is there a statistically significant correlation between the physical-based commodity market price and the futures market changes?

1.3. Overview on Methodology

In order to achieve the aforementioned objective, this dissertation will develop research activities using literature review and empirical analysis with time series data. In the literature review, the characteristics of the shipping market, market types and basic economic theories based on the demand and supply principle will be addressed in Chapter 2 in order to widen the scope of perspective of the shipping industry and
understanding of this thesis. Next, this dissertation will detect main points that could contribute to this dissertation through previous research activities on the study on volatility of BDI, commodity pricing mechanisms and financialization of the commodity market.

For the empirical test, sea borne trade volume of iron ore, coal, crude oil, grain, dead weight and industrial production were selected as variables representing demand and supply of shipping, and Open-Interest\(^2\) and Commodity Futures Position were considered as variables representing futures market conditions. This dissertation will find a best fit model against the aforementioned hypotheses using regression analysis based on actual data from the data sources, and verify estimated models according to assumptions of the Classical Linear Regression Model.

The methodology for the empirical test will be addressed in Chapter 4, and this dissertation will follow the working process for the effective analysis on market data as shown in Figure 3.

---

**Figure 3:** *Flowchart on data analysis using statistical program*

(Source: organized by author)

\(^2\) Open-Interest : represent the total number of outstanding contracts that are held by market participants
1.4. Overall organization of dissertation

This dissertation consists of six chapters. In Chapter 1, the background and objective of the dissertation are incorporated. Chapter 2 will discuss the main characteristics and notions of the overall shipping market and tramp business sector. Chapter 3 will review precedent research activities, and explore a different approach on data analysis between precedent research and this dissertation. Chapter 4 will present the methodology in detail for the effective empirical data analysis, and then in Chapter 5, this dissertation will try to find answers to the main questions in line with the aforementioned process. To sum up, conclusion and the necessity of further researches in terms of futuristic viewpoint will be addressed in Chapter 6.

Lastly, this dissertation described in advance that it is more difficult to find causality between variables than finding correlation between variables. Especially, for the analysis in the commodity market, there was difficulty in collecting data for the analysis of the causality between the physical commodity and the futures market. This is because most of the data was not publicly available. Furthermore, market conditions can be varied by economic reasons as well as non-economic perspectives, and the pricing mechanism in the freight market is highly complicated, volatile and unpredictable.
2. Understanding of the shipping industry

Prior to the beginning of full-scale research, this dissertation will briefly review the shipping industry to widen the background knowledge for easy approach to the topic. In this chapter, the nature of the shipping industry, the type of shipping market and the shipping market equilibrium based on the economic theories will be addressed.

2.1. The nature of the shipping industry

2.1.1. Definition and functions of shipping in global trade

According to Martin Stopford (2009), shipping was defined as a fascinating business since five thousand years ago. Shipping is a complicated market with fluctuating market conditions, with high risk, and it is usually in parallel with the cycle of global economy.

For the participants in the shipping industry, cyclicality is regarded as the nature of the shipping industry, and the shipping industry has experienced many peaks and troughs in the past. Currently, the shipping industry is highly dependent on the world economic growth. In fact, shipping accounted for approximately 90% of world trade demand for transport (DNV, 2012).

In this point, Rochdale (1970) defined the notion of shipping within the global logistics boundary as follows:
“Shipping is a complex industry and the conditions which govern its operations in one sector do not necessarily apply to another; it might even, for some purposes, be better regarded as a group of related industries. Its main assets, the ships themselves, vary widely in size and type; they provide the whole range of services for a variety of goods, whether over shorter or longer distances...”

Under the globalized economy, shipping is the necessary mode to facilitate the transportation of goods. Seaborne trade continues to expand, bringing prosperity through cost efficiency from an economic point of view. Owing to the development of efficiency of shipping as one of the modes of transport and the integration of economic activities among countries across the world, the prosperity for the industry's further growth continue to be sustainable and feasible (http://www.ics-shipping.org).

2.1.2. Main characteristics of the shipping industry

As a whole, the general economic theory and principles are simply applied to the computing cost of maritime transport, price discovery and production changes in the shipping industry. Given that the role of shipping is the transporting of cargo from the place of supply to the place for consuming goods, such particularity of shipping can be summarized as follows:

1) Demand on maritime transport is one of the derived demands from the backbone sector, such as demand for international transportation. That is, shipping does not create its intrinsic demand itself and naturally its demand came from the needs on trade of goods. As a means of transportation, shipping service cannot be stored and is different from the general type of service offered (Stopford, 2009).
2) Maritime transport is regarded as one of the most internationalized sector in the world. Such a high degree of internationalization of shipping is due to both the nature and the feature evolved from globalization. This means that the components of shipping are formed with the input and various elements of truly global sources across the world. Preceding the internationalization continuously, the shipping industry has a close connectivity with other business sectors such as commodity, financial market and infrastructure for transportation (Ma, 2014).

3) Open competition is another specified feature of maritime transport. In comparison to any other sectors, shipping is recognized as widely open market in terms of its business activities pattern and relatively low barrier for any new comers to enter into the market. In fact, according to international law, especially UNCLOS, the seas and oceans including national territorial waters are free for all ships to sail and pass regardless of the flag of ship. Commercially “cross-trading” is a common practice in shipping. Therefore, shipping is a nearly close to perfect competition market in terms of the viewpoint of general economic theory (Ma, 2014).

4) According to Canadian Encyclopedia (http://www.thecanadianencyclopedia.ca), the competitiveness of maritime transport is based on the principle of economy of scale. Floating and moving on water gives shipping a lot of advantages over other modes of transport because extraordinarily big amounts of cargo can be carried by an ocean-going ship at a time. Up to now shipping is considered as one of the least expensive transport modes for moving large quantities of goods at a time over long distances.

2.2. Types of shipping market

As mentioned earlier, shipping is a private, highly competitive service industry and is characterized to a great degree by market cycles and is a demand-driven sector. Shipping companies provide various types of service to satisfy the different needs of
customers in market, and these business activities incurred different modes of transportation for raw material (Ma, 2014).

For instance, natural resources including energy resources, metal and non-metal sources, agricultural products and forestry were listed as main cargo for trading (Stopford, 2009). Therefore, these give rise to three major segments in the shipping market, which will be referred to as liner, bulk and industrial shipping based on data depicting cargo type from world seaborne trade in 2012 (see Figure 4).

![Figure 4: The world seaborne trade (2012) in cargo-ton-mile by cargo type](Source: Reorganized by this dissertation based on Review of Maritime Transport, UNCTAD, 2014)

2.2.1. Tramp

At the beginning of the shipping history, tramp shipping used to be the only and commonly used type for maritime transportation. Even though it still accounts for the one pillar of shipping organization, at the moment tramp shipping is more used in the transportation of large quantities of homogeneous cargo due to the evolution of the shipping industry. Mostly, it is often engaged in primary commodities for the second tier of the production industry, which are commonly called bulk cargo (Ma, 2014).
According to a market report (Clarkson research studies, 2004), “the tramp shipping market” was defined as three main categories of bulk type cargo: liquid bulk including crude oil, oil products, and chemical goods. The shipment size of each consignment varies from a few thousand tons to half a million tons. Iron ore, grain, coal, phosphates and bauxite, which can be transported in the form of dried bulk, are regarded as the major bulks (Clarksons research studies, 2004).

Clarkson research studies (2004) defined that tramps were characterised as a particular general shipping service, maintaining neither having a regular service pattern nor being a special service in terms of routes and customers. Thus, the main characters of tramp shipping can be described by cargo type and service pattern as follows:

1) Operational features

Usually, ships engage in transportation based on cargo commitment, which is irregular in time and/or places. Time means a certain period for charterers who conclude transport contracts with ship owners and would like to use the ship for a period of time. This period can be varied from one month to six months or one year or even longer. Commercially exact chartering periods will be fixed each time by the parties concerned in the contract which was made individually (Clarksons research studies, 2004).

2) Organizational features

Most companies operating tramp shipping are small with a few ships in terms of economy of scale because an organizationally small company can give numerous advantages not only to each ship but also during the voyage. Moreover, each contract is made individually in fluctuating market conditions. Thus, tramp shipping is normally organized on a relatively small scale with a few ships in comparison to that
of a liner shipping company. In other words, the height of the entrance barrier existing in the tramp business is relatively lower than that of liner shipping (Clarkson's research studies, 2004).

3) Commercial characteristics

The tramp shipping market is close to the nearly perfect competitive market, which was usually mentioned in general economics textbooks because a lot of charterers, shipowners and brokers are actively participating in the tramp service (Stopford, 2009). The demand in tramp shipping is always changing irregularly, volatilely and constantly. Tramp shipping is normally regarded as a high risk business by many people and at the same time one of a speculative sector for some aspects.

2.2.2. Specialized (or Industrial)

Specialized shipping transports large quantities of "specialized" trades, generally using ships built for the specified purpose. Thus, most of shippers for the shipment of specialized cargo are originated from the second tier industry such as oil refinery, chemical companies and auto makers. Even though these ships are specially purpose built, the main character of specialized shipping is closely similar to that of tramp shipping in terms of irregular service patterns. The main cargoes can be categorized into the following (Clarksons Research Studies, 2004):

1) Refrigerated cargo

Refrigerated cargo is an obvious candidate for specialisation since it can only be carried in holds with refrigeration. This cargo has traditionally been the subject of intense competition between the liner business and specialised "reefer" ships. Specialised reefer ships have fully insulated cargo holds and refrigeration equipment (Branch, 2011).
2) Forest products

Forest products include logs, packaged timber, wood pulp bales, paper and wood chips. All of these cargoes could be transported by conventional bulk carriers, up to the 1960s, when shipowners started to build bulk carriers with special features designed for the efficient handling and stowage of forest products (Branch, 2011).

3) Motor vehicles

Motor vehicles can be carried in a wide range of different ship types, including multideck liners, multi-purpose vessels with fold-down decks, deep sea ro-ro vessels, in containers on containerships and purpose built vehicle carriers. They are generally designed with a fast speed and efficient loading and discharge of the cargo (Branch, 2011).

4) Gases transported as liquids, including LNG, LPG, and Chemicals

In order to transport gases by sea they must either be liquefied or pressurized. A fleet of specialized tankers has been constructed for this purpose. There are two main categories of ships. Liquid petroleum gas (LPG) tankers carry propane, butane, ammonia and a number of other chemicals (Clarksons Research Studies, 2004).

Commonly, tramp and specialized shipping has similarities in terms of shipment irregularity, frequency, and the transport routing, and timing are tailored to the need of the cargo. Therefore, this dissertation will focus on the main differences between tramp shipping, including specialized shipping, and liner shipping

2.2.3. Liner

On the contrary to tramp services, liner shipping is designed for the provision of regular services between specified ports, according to timetables and prices in advance (Branch, 2011). The service is in principle open to everyone with some
cargo to ship, and in this sense, it resembles a public transportation service in the ground area.

The provision of such a service covering a global range requires a wide range of business networks in terms of terminals and/or cargo handling facilities, ships, equipment, and agencies. Even though this magnitude investment into infrastructure may incur undesirable capital concentration, it will be a considerable barrier to entry for newcomers (Hensher & Button, 2007).

Cargo carried by liner shipping is known as general cargo. Until the beginning of the 1960s, such cargo was transported in various forms of packaging, such as pallets, boxes, barrels, and crates, by relatively small vessels. However, this situation started to change in the nineteen sixties with the introduction of containerization in the trade between the United States and Europe and, subsequently, in the rest of the world. Containerization is often described as a revolution in seaborne transport newcomers (Hensher & Button, 2007).

On the one hand, liner shipping is completely different from the main character and it consists of a number of special subsystems. Apart from the technical management, which is similar in both liner and tramp shipping, liner shipping has unique aspects in many ways.

1) Operational features

Liner shipping is a kind of maritime transport similar to airline, train and bus transport services. Liner shipping companies provide transport services with a prefixed sailing schedule linking fixed ports of call, named vessels and fixed prices in accordance with an openly published tariff system (Ma, 2014).

2) Organizational features

A liner company is normally a more well-organized, large and complex body than a tramp shipping company. Because cargo in liner shipping is generally small volume
and liner shipping companies have to deal with a great number of clients in each voyage. These kinds of service patterns needed in liner shipping normally produce a higher overhead cost, wide spread service network covering the globe and the necessity of information management and coordination efforts (Ma, 2014).

3) Commercial features

Traditionally, the pricing mechanism in liner shipping is complex too. Liner shipping used to have commodity based tariffs, which are a kind of pricing system with detailed commodity categorizations. One the other hand, containerization started from 1960’s and has had a great impact on the improvement of productivity and significant increase on liner shipping demand. In fact, the impact of containerization still goes well beyond the maritime transport system itself (Ma, 2014).

To sum up, liner shipping provides a relatively formulated service that is managed by fixed service routes and port rotation, and freight rate by published tariffs. A liner service was carried out as planned for on time delivery of cargo unless a call to ports had been unduly delayed by the nature or man-made causes. Tramp shipping is a business type in which there are no fixed routes or planned schedules to transport any cargo from loading to unloading place (Stopford, 2009).

2.3. Market equilibrium in the shipping industry

2.3.1. What is the market?

For understanding market equilibrium in the shipping industry, at first this dissertation implies what a market actually is through the definition by Jevons (1871). He clarified the main function of market at 19th century and stressed on the importance of trade between sellers and buyers. Definitely, basic concepts of market in Jevons’s definition are still valid in shipping industry even 21st century as follows;
“Originally a market was a public place in a town where provisions and other objects were exposed for sale; but the word has been generalized, so as to mean anybody of persons who are in intimate business relations and carry on extensive transactions in any commodity.”

Today, the types of seaborne transport are divided into the character of the market and trading commodities. The freight market for seaborne trade is composed of the sale and purchase market, second-hand ships market, new building and demolition market (Lun, Lai & Cheng, 2010).

2.3.2. Demand on shipping

As mentioned before, demand on seaborne trade is derived from the global trade needs and its market mechanism is still valid for the price discovery in shipping. Practically, demand for transport of physical commodities influence on demand for freight rates in the shipping industry. Stopford (2004) clarified the five determinants for sea transport influencing shipping demand: political factors, the world economic conditions, seaborne commodity trade, average haul, and transport costs.

1) Shipping Demand Curve

Lun, Lai and Cheng (2010) defined maritime demand in terms of general economic theory. They argued that the freight for maritime transport is a function of shipping demand and supply of ship commitment to meet shipping demand in certain time period. Similar to the shape of the demand curve in general economics, the demand curve for seaborne trade showed the downward slope to the right (Lun, Lai & Cheng, 2010).
In the same way as in the law of demand in general economics, the shipping demand curve describes that buyers will expand their willingness to pay when the freight rate falls, and oppositely will shrink their willingness to pay when the freight rate is up, as shown in Figure 5 (Lun, Lai & Cheng, 2010).

Even though a number of factors have an effect on the shipping demand, seaborne trade is one of the main components affecting the demand for sea transport. That is, the change of seaborne trade volume can incur a change in the demand for sea transport. For instance, an increase in seaborne trade volume will generate increasing demand on sea borne transport. It influences the demand curve to shift to the right, as shown in Figure 5. On the other hand, a decrease in demand for sea transport shifts the demand curve to the left direction (Lun, Lai & Cheng, 2010).

2) Elasticity of shipping demand curve

Theoretically, the relation between the shipping industry’s output and the fluctuation of freight rates can be explained by the notion of the seaborne transport elasticity of demand (Lun, Lai & Cheng, 2010). For example, the demand for tramp shipping is
closely related with the demand on transport of raw material, and the demand of transport of raw material depends on the fundamental economic conditions and end-user’s consumption tendency (Lun, Lai & Cheng, 2010). On the basis of these derived demand characteristics, Metaxas (1971) explained the characteristic of the elasticity of shipping demand as the following:

• The elasticity of demand for sea transport depends on the elasticity of consumer demand for the goods shipped by sea.

• The lower the cost of sea transport as a proportion of the total cost of the final goods, the more inelastic the demand for sea transport will be.

• The demand for sea transport tends to be price-inelastic in the short run.

To sum up, the elasticity of shipping demand against the freight rate is relatively inelastic because shippers and buyers have few options to avoid highly volatile market conditions for the fulfillment of the contract of carriage of goods.

2.3.3. Supply for the shipment of goods

Truett (1998) defined the notion of supply of ships as follows:

“Supply of sea transport is measured in terms of the supply of tonnage. All the ships that are trading in the freight market system ‘active shipping supply’. Ships that are not laid in trading constitute “available or potential shipping supply”

Truett (1998) emphasized that the concept of ton-mile should be considered as main factor affecting the shipping market and the notional meaning of ton-mile is that a unit of measurement for estimating the quantity of shipping services produced or available is the capacity-ton-mile per unit of time.
1) Shipping supply curve

Graphically, the freight rate on certain markets has strong impact on the supply of sea transport. The shipping supply functions explain that the quantity of shipping services supplied by carriers is decided by freight rate changes.

Graphically, there will be four types of slopes in the shipping supply curve: low freight rate, rising, high and premium freight rates. Moreover, the price elasticity of shipping supply can be considered as corresponding against the change of freight rates (Stopford, 2009)

Figure 6: Shipping supply curve
(Source: Martin Stopford, 2009)
2) Short-run and Long-run Shipping Supply

As can be seen in Figure 6, the supply of shipping capacity cannot immediately cope with the change of demand in the short term. Moreover, there is a time lag between ship owners’ decisions to increase the ship fleets and the actual time based ship commitment into the market. Thus, the supply of shipping capacity was referred to be inelastic against demand on shipping (Samuelson & Nordhaus, 1992).

3) Rigidity of shipping supply curve

Shipping is a capital intensive industry because a large amount of money is necessary to fulfill the fleet list. A ship’s average life cycle is considered about 25 years for the investment in new ships to be scrapped. Due to the long term interval between ordering a new ship and the delivery, it is natural that ship supply will be difficult to be elastic against the change of demand on seaborne trade (Fusillo, 2004).

To sum up, as before mentioned, the most important and fundamental finding is that the shipping industry is a more demand-driven market rather than supply driven. Furthermore, the demand on the shipping industry depends on world seaborne trade derived from economic growth. However, this dissertation will not discuss the degree of slope in the demand and supply curve, and the shape of the demand and supply curve. Instead of these curves, the results of previous research on the above questions will be generally accepted because it is beyond the scope of this dissertation topic.

2.3.4. Market equilibrium in the short-term

Similar to a general economic theory, the demand on sea transport indicates the maximum level of sea transport shippers are willing to pay at each level of the freight rate (Lun, Lai & Cheng, 2010).
However, the sea transport supply function implies the minimum level of sea transport carriers are willing to buy at each level of the freight rate. Eventually, by the price discovery of the freight market, the supply and demand curves cross at the balance point in the shipping market. At this point, both shippers and carriers reach a mutually agreement with an acceptable market freight rate level (Lun, Lai & Cheng, 2010).

Theoretically, market equilibrium in the shipping industry was achieved by the principle of demand and supply of shipping. The result of equilibrium in the freight market refers to a functional relationship between demand and supply of shipment. BDI, which was investigated into the next page, is one of the results of freight market equilibrium in tramp shipping (Kavussanos & Visvikis, 2006)
2.4. What is the Baltic Exchange Dry Index (BDI)?

BDI is an independent indicator representing market information for trading commodities, and the settlements of physical and derivatives instruments. BDI was developed by the Baltic Exchange and is considered as a leading indicator to international dry bulk shipping markets (Baltic Exchange, 2013).

2.4.1. The origin of BDI and trend at the time of 2008

The BDI was first introduced on 1 November 1999 to replace the Baltic Freight Index (BFI), which was the first shipping index published by the Baltic Exchange in 1985 (Zuccollo, 2013). Figure 8 shows the selected BDI data. The peak point of BDI is 11,793 points in 2008 and the bottom 647 points (Baltic Exchange, 2013).

Figure 8: The trend of BDI from 1985 to 2012
(Source: Blomberg)
Furthermore, Figure 8 shows that the overall trend of the BDI time series has been characterized by large amplitude of vibration, irregularity and nonstationary (Zeng & Qu, 2013). From November 1999 to early 2003, the trend of BDI changed moderately. After 2003, the market volatility increased and the curve reached its peak of 11,793 points on 20 May 2008, and decreased sharply to 663 points in the following 7 months.

2.4.2. Composition of BDI

According to the differences of ship sizes, the dry bulk shipping markets are divided into four types: Handysize, Supramax, Panamax and Capesize. The Baltic Exchange issues daily dry bulk shipping indexes of different ship sizes. The BDI is a composite index that is calculated as the equally weighted average of four sub-indices: The Baltic Handy Size index (BHSI), the Baltic Supramax index (BSI), the Baltic Panamax index (BPI) and the Baltic Capesize dry bulk shipping index (BCI) (Baltic Exchange, 2013).

Meanwhile, the Baltic Exchange (2013) stressed that the BDI has absorbed global shipping prices of various forms of dry bulk cargo across twenty-five key dry bulk shipping routes information. Furthermore, the Baltic Exchange claimed that these prices were obtained through the involvement of a neutral, independent, reputable and trustworthy panel of international ship brokers on a daily basis (Baltic Exchange, 2013).

1) The overall BDI is calculated as the weighted average cost of carriage of dry bulk cargo across these four indices, multiplied by a predetermined factor. This multiplier factor was first introduced when the BDI replaced the Baltic Freight Index (BFI) in 1999 and is used to standardize the BDI (Baltic Exchange, 2013). Mathematically, the formula used for the creation of the BDI may be expressed as follows:
(CapesizeTCavg + PanamaxTCavg + SupramaxTCavg + HandysizeTCavg) / 4 * 0.113473601

Where TCavg = Time Charter Average. (Source: Baltic exchange(2013))

2.4.3. Factors affecting the changes of BDI

The changes in economic activity across the world economies can influence the changes in the BDI (Oxford Economics, 2009).

1) Global commodity demand

To unearth the drivers of the BDI price, the Baltic Exchange (2013) identifies a number of variables. They explain that the BDI is driven by a large range of external factors and a number of fundamental drivers which underlie in all BDI price changes. The most fundamental of these drivers is the demand for shipment of commodities (Lun, Lai & Cheng, 2010).

2) Supply of ship in the short and long term

In the short term, the capital-intensive task of manufacturing a new cargo ship can take two to three years to complete. A sizeable investment cannot simply be entered into on a prompt decision making basis. As a result, ship-owners tend to order new ships during periods when global demand is strong and receive them a number of years later (Lun, Lai & Cheng, 2010).

3) Bunker Price
Generally, bunker prices account for about 25% - 33% of the total cost of operating costs for the shipment of goods (Baltic Exchange 2013). As a result of the fact that bunker prices are closely related to crude oil prices, the extremely volatile movements in the oil price directly affect ship owner’s decision making for new building vessel ordering and the change of BDI (Geman & Smith 2012).

Figure 9: Comparison of BDI and Euro-Adjusted WTI oil price
(Source: http://www.bloomberg.com/markets/commodities)

Figure 9, explained the movements in the crude oil price during the period 2007 – 2009. The sharp decline in the oil price after the financial crisis in 2008 is one example representing the volatility of crude oil price and cross market linkage between BDI and crude oil price.

4) Additional factors
The demand of the tramp business is derived from the global based trade of bulk type cargo, which is also affected by the global economic trend. Moreover, indirectly, climate change, business conditions in the demolition market and the second-hand ship market, and the ship building industry can have an influence on the demand of tramp transportation (Baltic Exchange, 2013).
3. Literature Review and Difference with Precedent Research

As reviewed in the previous chapters, the main questions for this dissertation came from the collapse of the BDI in 2008. In this chapter, the literature review on previous research to find the reason for the collapse of BDI in 2008 and differentiation between previous research and this dissertation will be addressed.

3.1. Review of precedent research

3.1.1. Characteristics of tramp market

Zeng and Qu (2013) used the method based on empirical decomposition to reflect the nonstationary and nonlinear nature of the price series of the bulk shipping market. In order to focus on the volatility of the bulk shipping market, they used econometric and statistical methods, such as VAR\(^3\), GARCH\(^4\) and VECM\(^5\) models shipping market analysis and forecasting. In their results they indicated that the log-linear model is not a good method for bulk shipping market forecasting.

Zuccollo (2013) investigated the formulation of BDI in depth and used correlation analysis for the empirical testing on the usefulness of the BDI in a South African economy. He claimed that the BDI is useful when used as a leading economic

\(^3\) VAR : Vector Auto Regression
\(^4\) GARCH : Generalized AutoRegressive Conditional Heteroskedasticity
\(^5\) VECM : Vector Error Correction Model
indicator in South Africa and suggested strong evidence to support the existence of a relationship between the BDI and the Johannesburg Stock Exchange Mining Index.

Ko (2013) focused on the business pattern in the Forward Freight Agreement (FFA) market situation at the time of 2013 in order to analyze the reason for the sharp fluctuation in the shipping market. He pointed out that the FFA market was affected by the changes of long position\(^6\) in futures market.

Wang and Lin (2014) studied the dynamic analysis of BDI using the fuzzy set theory and grey system for modeling the prediction of BDI, and employed the ARIMA\(^7\) model for the calibration of the data structure to depict the trend. As a result, they indicated that the fuzzy time series model has the lowest prediction error both short-term and long-term BDI data.

Frankel (2013) studied an econometric estimation model for price of oil and other storable commodities. He conducted empirical tests with an interest rate and commodity price index to find certain relation between monetary policy and the change of commodity prices in a time series analysis.

Apergis and Payne (2013) showed the utility of market information and the predictability of the BDI in the scope of financial assets and global economic system. In order to prove their claim, they used panel approaches and daily data from the period of 1985–2012 for the empirical analysis on the relation between the BDI, and financial assets and industrial production. The results of empirical tests stressed the functions of the BDI for the forecasting physical economy conditions.

Bakshi, Panayotov and Skoulakis (2011) explained that the growth rate of the BDI has forecasting ability for the stock market changes. They concluded that the predictability of the stock market is a significant finding from the empirical tests using the statistical tool.

---

\(^6\) Long position: it means a willingness to buy certain commodity in the future with specified price.

\(^7\) ARIMA: Auto Regression Integrated Mathematical Analysis
Using an EGARCH model, Yuwei, Shaoqiang, Yonghui and Hualong (2014) analyzed the reason for the seasonality, cyclicality and high volatility in bulk shipping and applied the EGARCH model to analyze the leverage effect among the four kinds of sub-indices in BDI. The results of empirical test indicated that all series of daily BDI rates of return clearly have leverage effects.

Batrinca (2013) showed the detailed explanation on the BDI with the literature and the decomposition of formulation of BDI. Through the comprehensive analysis on pricing mechanisms in the shipping market, he proved the role of useful and reliable information for the market equilibrium.

Lee (2011) researched the determinants of volatility in BDI through understanding the tramp market. In order to analyze the correlation between BDI and factors affecting the changes of BDI, he used correlation analysis and multi-regressions to test the hypothesis. Eventually, he insisted that the tramp shipping market is related with demand and supply of the market itself, as well as exogenous variables such as commodity prices and economic growth rate.

### 3.1.2. Characteristics of commodity market volatility

Flassbeck (2012) investigated the price formation in financialized commodity markets and insisted that the role of market information flow is crucial for price discovery in the commodity market since the mid-2000s. Furthermore, he pointed out that commodity transactions are not based on information reflecting fundamentals. Thus, a wide range of motivation leads market participants to engage in irrational decision making, so-called “intentional herding”

Cinquegrana (2008) argued the need of measures for transparency in commodity and commodity derivatives markets. He explained the fundamental pricing mechanism in commodity spot and futures market, and characteristics of commodity derivatives in future markets. With the explanation of the financial crisis, he stressed the
introduction of more transparent and stronger regulations in the commodity derivative market to mitigate the excessive speculation in commodities.

Masters (2008) gave a testimony on the reason of the financial crisis to the U.S. Senate. In his testimony, he aroused the danger of Index Speculators’ participation in future commodity markets and showed Index Speculator demand characteristics with the trend of the future commodity market size. Eventually, he argued that aggressive action taken by CFTC\(^\text{8}\) is necessary to strictly limit the position of speculators across all derivative markets.

Roh (2013) analyzed the main characteristics of commodity prices in the long term perspective and especially he observed the magnitude of financialisation in commodities using correlation analysis between future long position and commodity price index. He found that the connectivity between commodity prices and financial instruments increased in the mid-2000 and proved the connectivity by using a regression model.

Chiste and Vuuren (2014) studied the cyclical behaviour in the shipping market to facilitate investment on time. They found that the rule of thumb of 7 years did not show up in the recent shipping market and insisted that better understanding of the shipping industry can lead to mitigation of some vulnerability to market risks.

As a result, three main questions for this dissertation were extracted from the literature review as follows:

Table 1: Three main questions for this dissertation

<table>
<thead>
<tr>
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<th>Descriptions</th>
<th>Remark</th>
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<tbody>
<tr>
<td>Q1</td>
<td>Is there a statistically significant correlation between BDI and physical based sea borne trade volume?</td>
<td></td>
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\(^8\) Commodity Futures Trading Commission
Q2  | Is there a statistically significant correlation between BDI and physical based commodity market price?
---|---
Q3  | Is there a statistically significant correlation between physical based commodity market price and futures market changes?

### 3.1.3. Lessons from precedent research

1) Using multiple regression analysis

In order to test the correlation between BDI and explanatory variables, this dissertation will apply multiple-regression analysis to detect the correlation between dependent variable BDI and explanatory variables because regression analysis is widely used to find correlation between variables.

Then it can make a contribution to measuring the magnitude of explanatory variable of importance. Even if there are single regression and multiple-regression analysis in statistics, multiple-regression analysis will be applied to this dissertation.

However, in case of using multiple regression analysis, there is possibility of facing the problem of correlation between the explanatory variables, the so-called multicollinearity problem (Visvikis, 2015). It is a phenomenon where two or more of the explanatory variables used in a regression model are highly related to one another in model (Brooks, 2014).

2) Using Logarithm price

Data in empirical tests have their own unit scale. For instance, the fundamental unit representing commodity prices is U.S. Dollars in most cases, but varied economic indicators are published by indices values. Therefore, natural logarithms will be applied in this dissertation in order to eliminate the difference of unit in the data. If
logarithms were applied to each variable, the value of each variable can be changed into the effect of the rate of change of one variable on the rate of change of another (Brooks, 2014).

3.2. The differentiation on methodology with precedent research

3.2.1. Classifying variables into physical and derivatives markets

In order to clarify the magnitude of correlation between BDI and the physical market or derivatives market based variables, physical market based variables were divided into two groups: Those based on sea borne trade volume and those on physical commodity price corresponding to each based volume variables. That is, for the analysis on the relation between BDI and physical market, a fundamental notion is laid in the comparison of the magnitude of causality\(^9\) between sea borne trade volume variables and commodity price variables. However, explanatory variables used in most of previous research are put into the model without the classifying variables by market segments.

3.2.2. Finding reasons from the correlation and causality

As mentioned by Brooks (2014), correlation does not mean the meaning of cause and effect relation, as shown below:

“The correlation between two variables measures the degree of linear association between them. If it is stated that y and x are correlated, it means that y and x are being treated in a completely symmetrical way. Thus, it is not implied that changes in x cause changes in y, or indeed that changes in y cause changes in x”

\(^9\)Causality: it means relation between cause and effect.
Having a notion of causality, this dissertation will focus on finding the reasons for the collapse of BDI in 2008 through verifying the relationship between a dependent variable and several independent variables. This dissertation used the relation between BDI and sea borne trade volume, BDI and commodity prices, and commodity prices used in the former and future markets to find reasons for the collapse of BDI in 2008.
4. Methodology and Overview on the collapse of BDI in 2008

Prior to the empirical tests to identify the correlation and causality between BDI and the explanatory variables affecting the collapse of BDI, this dissertation takes a general view of the financial crisis in 2008 and methodology for data analysis in detail.

4.1. Market conditions at the time of financial crisis in 2008

According to Claessens and Kose (2013), a financial crisis was defined at a certain level of extreme manifestations of the cross relations between the financial sector and the physical based economy, which includes the following phenomena:

“substantial changes in credit volume and asset prices; severe disruptions in financial intermediation and the supply of external financing to various actors in the economy; large scale balance sheet problems of firms, households, financial intermediaries and sovereigns”

At the beginning stage of the financial crisis by the U.S. sub-prime mortgage loan, the shipping industry did not seriously acknowledge the possibility that the aftermath from the financial crisis could be transmitted into other non-financial sectors with another type of crisis. However, the seaborne trade demand for the shipment of raw material and steel products was continuously increased up to May 2008. Moreover, 11,793 points of the BDI was at the highest level in its history and the shipping
industry experienced a booming market too (Claessens & Kose, 2013).

However, the bankruptcy of a lot of U.S. investment banks, which happened in September 2008, led the financial market into panic and such a panic situation spilled over the entire industry including the shipping sector (CFTC, 2008). After the magnitude of the dangerous aftermath of the financial crisis in 2008, BDI sharply plunged by 94% from 11,793 points to 663 points in December 2008 within 7 months. In fact, seven years after the crisis, the aftermath of the financial crisis is still ongoing in the shipping industry as observed in the low levels of BDI.

4.2. Outline of the empirical analysis

4.2.1. Setting up hypotheses

At first, from the aspect of demand and supply in shipping, this dissertation assumed that the change of demand on physical seaborne trade volume has influenced the BDI and the change of the price on commodity markets also has some effect on the BDI. Obviously, the BDI can be affected by ship supply conditions in terms of long and short term. Therefore, this dissertation proposed three hypotheses as follows:

1. Is there a statistically significant correlation between BDI and physical-based seaborne trade volume?

2. Is there a statistically significant correlation between BDI and physical-based commodity market price?

3. Is there a statistically significant correlation between physical-based commodity market price and futures market changes?

10 Physical-based Commodity Market price means the price of commodity in spot market, not price in the derivative market.
4.2.2. The establishment of models

This dissertation set up three equations for finding the relationship between BDI and variables related with each market segments. In addition, each equation will be tested two times, before crisis and after the crisis, respectively. For these tests, three equations are created as follows:

To find a relation between BDI and variables representing sea borne trade volume, this dissertation makes the following equations:

\[
Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + U_t \quad \text{Equation ①}
\]

Where \( Y = \) BDI, the dependent variable
\( X_1 = \) Iron Ore Trade Volume, \( X_2 = \) Coal Trade Volume,
\( X_3 = \) Grain Trade Volume, \( X_4 = \) Supply of ship(DWT),
\( U_t = \) Sum of residuals (error terms)

In order to investigate relation between BDI and commodities price related with variables using in equation ①

\[
Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + U_t \quad \text{Equation ②}
\]

Where \( Y = \) BDI, the dependent variable
\( X_1 = \) Price of Iron Ore, \( X_2 = \) Price of Coal,
\( X_3 = \) Price of Grain, \( X_4 = \) Supply of ship(DWT),
\( U_t = \) Sum of residuals (error terms)

In order to investigate the relation between the commodity price used in equation ② and variables representing the financial market,
\[ Y = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + U_t \]  
\text{Equation ③}

Where \( Y \) = Commodity Price  
\( X_1 \) = Outstanding Open-Interest, \( X_2 \) = Net position in futures market, \( U_t \) = Sum of residuals (error terms)

4.2.3. The establishment of analysis period

In order to find the reasons for the collapse of BDI in 2008, this dissertation broke down the analysis period with the crisis before and the crisis after according to the critical point of 2008.

Through the comparison before and after the crisis, this dissertation will investigate the difference in the magnitude of individual influence of each variable against BDI in terms of before crisis and after crisis. On the one hand, the analysis period starts from January 2002 in line with the seven years cyclical pattern in shipping industry, as shown in Figure 10.

![Figure 10: The break-down of analysis period](Source: Organized by the author)

\(^{11}\) It consists of commodities price of each item using in equation ②, and it was calculated by logarithm price against physical based market price
4.2.4. Selection and description of variables

1) Demand side variables relating with sea borne trade volume

- Global Trade in Iron Ore

Iron ore is the source of primary iron for the world's iron and steel industries. Especially, iron ore exports directly link with the global output of crude steel production and it is one of 5 major bulk cargos in trade volume. In addition, it is mainly used as a main source of steel production and it is regarded as a key factor affecting the demand on dry bulk cargo. In fact, about 98% of iron ore is used for the steel industry (UNCTAD, 2015).

![World seaborne iron ore trade volume (Million tonnes)](Source: Clarksons Reasearch, Volume 21, No. 8, 2015)

- Coal

Coal provides 30.1% of total global primary energy needs and accounts for 40% of the world's electricity (www.worldcoal.org). It is also considered as one of the main sources for steel making. In this regard, this dissertation selected coal as a variable. Because it is mainly used for the production in the steel industry and electricity and it is also one of 5 major bulk cargos in terms of volume (Clarksons Research, 2015)
- Grain

Even though grain is one of 5 major bulks in both economic and shipping terms, it is a different business compared to others. Iron ore and coal are closely related with primary industry such as steel making and energy production, but grain has a direct effect on the human-being life. Total world grain trade volume in the year 2013/2014 increased by 10.0 percent to 4.29 million (Clarksons Research, 2015).
**Crude Oil**

In 2014, sea borne based crude oil trade accounted for about 17.1% of world total sea borne trade. According to OECD’s GDP forecast for major countries in 2015, demand on crude oil highly supports the world economy growth rate. As can be seen in Figure 14, the crude oil trade pattern is largely fluctuating and there is no specified trade pattern (UNCTAD, 2015).

![Figure 14: World seaborne crude oil trade volume (Million tonnes)](Source: Clarksons Reasearch, Volume 21, No. 8, 2015)

**Industrial Production**

The Federal Reserve of Bureau (http://www.federalreserve.gov) depicted that industrial production is one of the tools to measure the output of the industrial sector of a specific economy. The industrial sector includes manufacturing, mining, and utilities. Although these sectors contribute only a small portion of GDP, they have a high influence on the economic indicators such as interest rates, economic policy and consumer demand. This can be an important tool for forecasting future GDP and economic performance. In fact industrial production can be used as a substitution of monthly based GDP growth rate because it can reflect domestic economic activities (http://www.federalreserve.gov).
Open Interest

As a glossary used in the derivative market, open interest represents the total number of outstanding contracts that are held by market participants at the end of each day. The increase of open interest indicates that new money is flowing into the marketplace. Oppositely, declining open interest means that the market will be changed into the recession and the boom market trend will come to an end soon. Therefore, open interest can give a signal to participants in the derivative market for their decision making (http://www.cftc.gov).

Commodity Futures Position

A long position means a market position that imposes on the holder to buy a commodity in a specific time; on the contrary, a short position is imposed on the holder to sell a commodity. The net commodity futures position computed by the change of long and short position on futures markets means the change of money inflow from the outside derivative market (UNCTAD, 2011). For instance, Barrionuevo and Anderson (2007) insisted that the passing of the financial crisis in 2008, such money inflow into the derivative market from financial institutions was regarded as a main reason influencing future contracts.

2) Supply side variable (Ship Dead Weight Tonnage)

The supply of ships is determined by shipowners, shippers/charterers, and the bankers who finance shipping. Among the major four groups affecting the supply of ships, shipowners are the main decision-makers because they have a direct effect on the freight market through the decision making for ordering new ships, scrapping and

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12 Derivative Market, it is the financial market for derivatives, financial instruments like futures contracts or options, which are derived from other forms of assets. It is usually used for the commodity trading in specific time and price in the future.
the time for laying up tonnage. Moreover, the supply of shipping services based on monthly data tended to be steadily increasing from January 2004 up to September 2008 with the average increasing rate of 0.5% per month as shown in Figure 15 (Clarksons Research, 2015)

![Figure 15: The monthly based change rate of ship commitment](image)

(Source: Organized by author based on Data from Clarksons Research)

### 4.2.5. Data Collection

In order to undertake empirical tests, data used in the testing model were collected as follows.

Clarkson research was utilized in order to access BDI prices and monthly based sea borne trade volume of iron ore\(^{13}\), coal\(^{14}\) and grain\(^{15}\). As can be seen in the following,

---

\(^{13}\)Iron Ore was summed up data from export countries; Australia, Brazil, Canada, Chile, EU, India, Russia, Republic of South Africa, Ukraine.

\(^{14}\)Coal was summed up data from export countries; Australia, Canada, U.S.A. for Coking Coal and Australia, Canada, China, Columbia, Indonesia, Republic of South Africa, U.S.A., Venezuela for steam Coal
this dissertation summed up monthly based exporting cargo quantities by individual
countries’ statistics.

However, the monthly based trade volume of crude oil was obtained from the Joint
Organizations Data Initiative (JODI), whose initiative consists of seven partners
having an international level of reputation. All of the commodity price indices came
from The World Bank. The World Bank data contain physical based commodity
market prices on each variable.

The data collection period started from January 2002 to December 2014 and data
frequency is based on monthly data. All time-series data were transformed into
logarithms. Taking logarithms, time-series data can be more stationary state and an
exponential trend change into linear after logarithms. Moreover, it can often help to
rescale the data so that their variance is more constant (Brooks, 2014).

4.2.6. How to verify three hypotheses?

In order to perform multiple regressions in this dissertation, a traditional regression
method will be applied to Unit Root tests to verify the stationarity of variables and
next run regressions to find the explanatory power of each equation, respectively.
That is, the main scopes of the regression method are to find causality through the
correlation between dependent and independent variables. Through these tests, this
dissertation can make sure that the variables used in this test are at a stationary state
and then input the data to the regression model to perform the test (Visvikis, 2015).

1) Stationarity on variables by unit root test

Unit Root tests are tests showing whether a variable has the stationarity or not.
Otherwise, time series can strongly influence its behaviour and properties. Non
stationary variables in the regression model can be proved that the standard
assumptions for asymptotic analysis will not be valid (Dickey & Fuller, 1979). That

---

15 Grain was summed up data from export countries; Argentina, Australia, Canada, U.S.A.
is, hypothesis tests cannot be validly performed by the regression parameters. In this dissertation, the critical and p-values are set up at 95% significance level. It is considered as Variable having p-value of 95% or more (that is less than 0.05) or with a test statistic of less than the critical value is standard for determining significance of variables in relation to the hypothesis (Brooks, 2014).

2) Verifying correlation\(^{16}\)

As can be seen, the correlation among variables means the degree of linear relation between them. It does not mean cause and effect relation, the so called causality. Kenny (2004) explained a causal statement of that causality has two components: a cause and an effect, and it consists of three commonly accepted conditions, which have to be hold for scientific claim that X causes Y:

1. Time precedence, 2. Relationship, 3. Nonspuriousness

The relationship is the second necessary condition for causation. It means that if there is no relationship between variables, the next step is not able to continue finding causality between variables (Kenny, 2004)

3) Verifying the statistical significance of variables by T-test

The T-test and P-value are used to assess whether or not an explanatory variable is statistically significant. The null hypothesis is that the coefficient is equal to zero and consequently is not helping the model. When the probability is very small, the chance of the coefficient being essentially zero is also small. That is, a variable is seen as a significant if the P-value\(^{17}\) is less than the significance level or the Test statistic is greater than the critical value (Brooks, 2014).

---

\(^{16}\) Correlation: it means that there is co-movement between variables and it does not mean that there is causality between variables. Correlation is one of prerequisite conditions to meet the conditions for causality.

\(^{17}\) P-value gives the plausibility of the null hypothesis and it means that 5% of probability could be wrong by biased judgment.
4) Diagnostic tests: assumptions\textsuperscript{18} of Classical Linear Regression Model (CLRM)

- The F-Statistic Test (Wald Test) is a way of testing the significance of particular explanatory variables in a statistical model to assess the statistical significance and the fitness of the model overall (Brooks, 2014). If the probability of F-statistic is greater than 5%, the statistical significance of the model is acceptable.

- The White-test is applied to the model for detecting heteroscedasticity. It assumes that the regression model estimated is of standard linear. If the probability of F-statistic is bigger than the significance level of 5%, it means that the model has a Homoscedasticity and satisfies CLRM assumptions requirement (Brooks, 2014).

- For detecting serial correlation, the Breusch-Godfrey test was conducted to determine if the explanatory variables in the model have a consistent relation to the dependent variable. It assumes that the relationship is between an error and the previous one. If the probability of F-statistic is greater than the significance level of 5%, it means rejection of the error terms in the regression equation are uncorrelated with one another Cov (ui, uj) = 0 (Brooks, 2014).

- With regard to detecting Multicollinearity, the assumption is that the model is linear and the Ramsey test is used to detect multicollinearity in the model. It indicates that an appropriate model should be linear in terms of functional form (Brooks, 2014). If the probability of F-statistic is greater than a critical value then the null hypothesis should be rejected.

\textsuperscript{18} For making regression model, it means that estimated model have goodness of Fit statistics for the finding causality and forecast so far as it satisfy four basic assumptions;
- The errors have zero mean,
- The variance of the error is constant and finite(detection of heteroscedasticity)
- The errors are statistically independent of one another(detecting serial correlation)
- No relation between the error and corresponding x variate (detecting multicollinearity)
After the completion of diagnostic tests on regression model in line with assumptions of the CLRM, eventually this dissertation will come to a conclusion by comparing the analysis of the explanatory power of estimation model in terms of which estimation model can more significantly\textsuperscript{19} explain the influence between dependent variable and independent variable.

### 4.2.7. Interpretation on the result of empirical tests

1) Interpretation of the correlation coefficient

Surely, even though correlation between variables also has a significant meaning from an economic point of view, the correlation itself does not mean the meaning of causality.

In order to continue the test on the causality between variables, there should be significant correlation between variables because correlation is a requisite for the establishment of causality between variables (Williams, 2015).

This dissertation will use the criteria for assessing the significance of correlation coefficients, which was suggested by Rea and Parker (2005) in their book “Designing & Conducting Survey Research a comprehensive Guide.

They showed six criteria to assess the strength of correlation as follows. In addition, for the assessment of correlation coefficients, this dissertation will follow the guideline suggested by them. On the other hand, all of the statistical values produced by the empirical tests will be interpreted by the generally accepted notions of econometrics.

\textsuperscript{19} Significant: it means that there is a statistically meaningful for the judgment of certain result or certain phenomena and it does not mean the meaning in terms of the economic or political or another social scientific point of view.
Table 2: *The Criteria for the assessment of correlation coefficient*

<table>
<thead>
<tr>
<th>Magnitude of Coefficient</th>
<th>Interpretations</th>
</tr>
</thead>
<tbody>
<tr>
<td>from 0.0 ~ up to 0.1</td>
<td>Little correlation</td>
</tr>
<tr>
<td>over 0.1 ~ up to 0.2</td>
<td>Weak correlation</td>
</tr>
<tr>
<td>over 0.2 ~ up to 0.4</td>
<td>Moderate correlation</td>
</tr>
<tr>
<td><strong>over 0.4 ~ up to 0.6</strong></td>
<td><strong>Relatively strong correlation</strong></td>
</tr>
<tr>
<td>over 0.6 ~ up to 0.8</td>
<td>Strong correlation</td>
</tr>
<tr>
<td>over 0.8 ~ up to 1.0</td>
<td>Very strong correlation</td>
</tr>
</tbody>
</table>

(Source: Rea & Parker, 2005)

2) Approaching to the freight market equilibrium with short term perspective

The main goal of this dissertation is to find the reason for the collapse of BDI within seven months at the time of 2008. Taking into consideration that the freight market is nearly close to the perfect competition market, this dissertation regarded the ship Dead Weight as only one variable representing the supply side of the freight market to clarify the short term equilibrium.

4.2.8. How to precede empirical tests?

At first, this dissertation will start with the empirical test on each Question. In fact, Question 1 was designed to find a relation between BDI and sea borne trade volume through regression analysis. After that, the empirical test against Question 2 and Question 3 will be carried out. (See Figure 16).
Figure 16: Flowchart on Data analysis using statistical program
(Source: organized by author)
5. Empirical Tests

In order to find the reasons for the collapse of BDI in 2008, this dissertation investigates economic relations between the BDI and seaborne trade volume, BDI and physical based commodity prices, and physical based commodity prices and financial market variables in terms of before and after crisis.

5.1. Before the financial crisis in 2008

5.1.1. The causality between BDI and seaborne trade volume

1) Unit Root Test and Correlation

The results of the Unit Root Tests to investigate stationary of variables, seven variables including BDI were used to test stationary of data in the model. Even though BDI and trade volume of grain showed to be stationary, correlation coefficients of all explanatory variables against BDI showed up less than 0.10.

It means that practically there was no statistically significant correlation between BDI and sea borne trade volume. Thus, this dissertation did not continue to progress to the next tests because it is difficult to regard if BDI is correlated with trade volume of cargo in terms of the criteria for the assessment of correlation coefficient.20

20 It was designed by Rea & Parker (2005) and cited in chapter 4 of this dissertation
Table 3: Coefficient between BDI and trade volume

<table>
<thead>
<tr>
<th></th>
<th>BDI</th>
<th>Iron Ore</th>
<th>Coal</th>
<th>Crude Oil</th>
<th>Grain</th>
<th>Industrial Production</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>1</td>
<td>0.080</td>
<td>0.035</td>
<td>-0.047</td>
<td>0.676</td>
<td>0.013</td>
<td>0.321</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>0.080</td>
<td>1</td>
<td>0.039</td>
<td>0.032</td>
<td>0.066</td>
<td>0.168</td>
<td>-0.065</td>
</tr>
<tr>
<td>Coal</td>
<td>0.035</td>
<td>0.039</td>
<td>1</td>
<td>-0.042</td>
<td>0.126</td>
<td>-0.031</td>
<td>-0.028</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>-0.047</td>
<td>0.032</td>
<td>-0.042</td>
<td>1</td>
<td>-0.174</td>
<td>-0.015</td>
<td>-0.037</td>
</tr>
<tr>
<td>Grain</td>
<td>0.676</td>
<td>0.066</td>
<td>0.126</td>
<td>-0.174</td>
<td>1</td>
<td>0.078</td>
<td>0.408</td>
</tr>
<tr>
<td>Production</td>
<td>0.013</td>
<td>0.168</td>
<td>-0.031</td>
<td>-0.015</td>
<td>0.078</td>
<td>1</td>
<td>-0.138</td>
</tr>
<tr>
<td>DWT</td>
<td>0.321</td>
<td>-0.065</td>
<td>-0.028</td>
<td>-0.037</td>
<td>0.408</td>
<td>-0.138</td>
<td>1</td>
</tr>
</tbody>
</table>

5.1.2. The causality between BDI and Commodity Price

1) Unit Root Test

BDI among seven variables used to test the stationary of data in the model showed the stationary state and the others were showed as non-stationary in the initial test. However, all non-stationary variables were converted into stationary variables by the functions of 1st difference in Eviews\textsuperscript{21}. Eventually, stationary variables were input to the next process for the data analysis (Brooks, 2014).

Table 4: The initial result of the Unit Root Test on commodity price

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller\textsuperscript{22}</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-stat</td>
<td>5% Cr.value</td>
</tr>
</tbody>
</table>

\textsuperscript{21} Eviews: this is a program for the quantitative analysis of data in this dissertation

\textsuperscript{22} It is one of test way invented by Dickey and Fuller in 1981 to investigate data stationarity
<table>
<thead>
<tr>
<th></th>
<th>BDI</th>
<th>Iron Ore</th>
<th>Coal</th>
<th>Crude Oil</th>
<th>Grain</th>
<th>Industrial Production</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>1</td>
<td>-0.029</td>
<td><strong>0.386</strong></td>
<td><strong>0.203</strong></td>
<td>0.075</td>
<td>0.013</td>
<td><strong>0.321</strong></td>
</tr>
<tr>
<td>Iron</td>
<td>-0.029</td>
<td>1</td>
<td>0.408</td>
<td>0.522</td>
<td>0.232</td>
<td>0.107</td>
<td>-0.063</td>
</tr>
<tr>
<td>Coal</td>
<td><strong>0.386</strong></td>
<td>0.408</td>
<td>1</td>
<td>0.524</td>
<td>0.261</td>
<td>0.064</td>
<td>-0.088</td>
</tr>
<tr>
<td>Crude</td>
<td><strong>0.203</strong></td>
<td>0.522</td>
<td>0.524</td>
<td>1</td>
<td>0.213</td>
<td>0.093</td>
<td>-0.192</td>
</tr>
<tr>
<td>Grain</td>
<td>0.075</td>
<td>0.232</td>
<td>0.261</td>
<td>0.213</td>
<td>1</td>
<td>0.053</td>
<td>-0.115</td>
</tr>
<tr>
<td>Production</td>
<td>0.013</td>
<td>0.107</td>
<td>0.064</td>
<td>0.093</td>
<td>0.053</td>
<td>1</td>
<td>-0.138</td>
</tr>
<tr>
<td>DWT</td>
<td><strong>0.321</strong></td>
<td>-0.063</td>
<td>-0.088</td>
<td>-0.192</td>
<td>-0.115</td>
<td>-0.138</td>
<td>1</td>
</tr>
</tbody>
</table>

2) Correlation

The price of coal, dead weight and crude oil has relatively high correlation with BDI in terms of correlation coefficient 0.38, 0.32 and 0.20, respectively. And the other variables showed up less than coefficient 0.10. Coefficient between explanatory variables exhibits in coal-crude oil with 0.52 and iron ore-crude oil 0.52.

Table 5: Coefficient between BDI and commodity price

---

23 Production: it means an industrial production in this chapter
3) T-Tests for significance of model

Through the T-test for all variables and T-test for significant variable, the price of coal, price of iron ore and dead weight were judged as significant variables. It indicates that probability of three variables is less than the significant level of 0.05. In addition, adjusted $R^2$ 0.28 means that the change of explanatory variables in this model have 28% of explainable power to the change of dependent variable BDI.

Table 6: T-Test for significant variables

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std Error</th>
<th>T-Statistic</th>
<th>Prob</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>2,111.173</td>
<td>552.967</td>
<td>3.8179</td>
<td>0.0003</td>
<td>0.289</td>
</tr>
<tr>
<td>Coal Price</td>
<td>14,897.450</td>
<td>3,014.886</td>
<td>4.9412</td>
<td>0.0000</td>
<td></td>
</tr>
<tr>
<td>Iron Ore Price</td>
<td>-10,295.940</td>
<td>4,917.712</td>
<td>-2.0936</td>
<td>0.0395</td>
<td></td>
</tr>
<tr>
<td>DWT$^{24}$</td>
<td>408,360.100</td>
<td>108,215.900</td>
<td>3.7735</td>
<td>0.0003</td>
<td></td>
</tr>
</tbody>
</table>

4) Investigating violations of the assumptions of the CLRM$^{25}$

To verify the goodness of the estimated model as mentioned before, this dissertation undertook detecting Heteroscedasticity, Serial correlation and Stability test for the model in order as follows. According to the following results, this dissertation confirmed that the model has statistically satisfied the CLRM’s assumptions; Homoscedasticity and Stability. In case of Serial correlation test, the model was corrected by Newey West in order to eliminate Serial correlation (West, 1987).

$^{24}$ DWT : Abbreviation of Dead Weight Tonnage

$^{25}$ CLRM : Abbreviation of Classical Linear Regression Model
Table 7: Investigating violations of the assumptions of the CLRM

<table>
<thead>
<tr>
<th></th>
<th>F-Statistic</th>
<th>Prob</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteroscedasticity</td>
<td>0.7471</td>
<td>0.6647</td>
<td>Prob. F(9,73)</td>
</tr>
<tr>
<td>Serial Correlation</td>
<td>13.1853</td>
<td>0.0000</td>
<td>Prob. F(10, 69), Corrected by Newey West</td>
</tr>
<tr>
<td>Stability Ramsey</td>
<td>0.1709</td>
<td>0.6804</td>
<td>Prob. F(1, 78)</td>
</tr>
</tbody>
</table>

5) Final Formula

In this formula, it can be inferred that the influence power of dead weight which represents the supply side in the pricing mechanism accounted for 94.3% point\(^{26}\) of the total changing scale of BDI by explanatory variables up to the financial crisis in 2008. On the one hand, BDI showed the co-movement with ship supply before the crisis happened in 2008. It implies that as mentioned in Figure 7, the sharp decline of the freight rate can be explained by the nature of the supply curve that the supply curve becomes almost vertical after passing high freight rate\(^{27}\) up to premium freight rate\(^{28}\) level.

\[
Y_t = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + U_t \quad \text{Equation (2)}
\]

\[
Y_t = 2,111.1 + 14,897.45 \cdot X_1 - 10,295.9 \cdot X_2 + 408,360.1 \cdot X_3 + U_t
\]

(Adjusted \(R^2\) : 28.9%)

Where \(Y = \text{BDI, the dependent variable}
\]

\[
X_1 = \text{Coal Price} \quad X_3 = \text{Dead Weight}
\]

\[
X_2 = \text{Iron Ore Price} \quad U_t = \text{Sum of residuals (error terms)}
\]

\(^{26}\) 94.3% = Coefficient of Dead Weight / \(\Sigma\) (Absolute value of Coefficient of all variables excluding constant)

\(^{27}\) High Freight rate: all ships operational and running at full speed to meet the demand on shipping (Stopford, 2009).

\(^{28}\) Premium Freight rate: No further sea transport available until new ships delivered (Stopford, 2009)
5.1.3. The causality between commodity Price and financial market variables

1) Unit Root Test

As can be seen in Table 8, Commodity Price is only a stationary variable in the initial test. However, all non-stationary variables were converted into stationary variables by the functions of 1st difference in Eviews. Eventually, stationary variables were input to the next process for the data analysis.

Table 8: The initial result of Unit Root Test on financial market

<table>
<thead>
<tr>
<th>Variable</th>
<th>Augmented Dickey-Fuller</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T-stat</td>
<td>5% Cr.value</td>
</tr>
<tr>
<td>Commodity Price</td>
<td>-4.569</td>
<td>-2.897</td>
</tr>
<tr>
<td>Net Futures Position</td>
<td>-0.247</td>
<td>-2.898</td>
</tr>
<tr>
<td>Open-interest</td>
<td>-1.561</td>
<td>-2.900</td>
</tr>
</tbody>
</table>

2) Correlation

Overall, correlation coefficient between variables demonstrates around 0.15. Especially, coefficient between dependent variable (commodity price) and net futures position show up with 0.02 coefficients.

29 Commodity Price; it was based on physical market price and calculated by logarithm price
30 It represent the activities of financial market participants such as investment bank, private equity fund and pension fund covering the world financial market
31 It is one of test way invented by Dickey and Fuller in 1981 to investigate data stationarity
Table 9: *Coefficient between commodity price and financial market*

<table>
<thead>
<tr>
<th>Commodity Price</th>
<th>Net Futures Position</th>
<th>Open-interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity Price</td>
<td>1</td>
<td>0.027</td>
</tr>
<tr>
<td>Net Futures Position</td>
<td>0.027</td>
<td>1</td>
</tr>
<tr>
<td>Open-interest</td>
<td>0.155</td>
<td>0.169</td>
</tr>
</tbody>
</table>

3) T-Tests for significance of model

Through the T-test for all variables and T-test for significant variable, Open-Interest was selected as a significant explanatory variable for the model and the estimated model is as shown in Table 10.

It indicates that the probability of three variables is less than the significance level of 0.05. In addition, adjusted $R^2$ 0.04 means that the change of explanatory variables in this model have 4% of explainable power to the change of dependent variable. In comparison with $R^2$ of equation ②, $R^2$ 0.04 is relatively low.

Table 10: *T-Test for significant variables*

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std Error</th>
<th>T-Statistic</th>
<th>Prob</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.006715</td>
<td>0.006386</td>
<td>1.051533</td>
<td>0.2962</td>
<td>0.04</td>
</tr>
<tr>
<td>Open-Interest</td>
<td>0.237870</td>
<td>0.105779</td>
<td>2.248746</td>
<td>0.0273</td>
<td></td>
</tr>
</tbody>
</table>

4) Investigating violations of the Assumptions of the CLRM
To verify the goodness of estimated model as mentioned before, this dissertation undertook detecting Heteroscedasticity, Serial correlation and Stability test for model in order as follows. According to the following results, this dissertation confirmed that the model has statistically satisfied the CLRM’s assumptions; Homoscedasticity and Stability. **In case of Serial correlation test, the model was corrected by Newey West in order to eliminate Serial correlation** (West, 1987).

Table 11: *Investigating violations of the assumptions of the CLRM*

<table>
<thead>
<tr>
<th></th>
<th>F-Statistic</th>
<th>Prob</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteroscedasticity</td>
<td>1.2449</td>
<td>0.2935</td>
<td>Prob. F(2,79)</td>
</tr>
<tr>
<td>Serial Correlation</td>
<td>3.7019</td>
<td>0.0005</td>
<td>Prob. F(10, 70), Corrected by Newey West</td>
</tr>
<tr>
<td>Stability Ramsey</td>
<td>0.2033</td>
<td>0.6533</td>
<td>Prob. F(1, 79)</td>
</tr>
</tbody>
</table>

5) Final Formulas

The explanatory power of this formula is relatively low, so that it is difficult to find the causality between Commodity Price and Open-Interest.

\[
Y_t = \beta_0 + \beta_1 \cdot X_1 + U_t \quad \text{----------------------------------------------- Equation ③}
\]

\[
Y_t = 0.0067 + 0.2378 \cdot X_1 + U_t \quad \text{(Adjusted } R^2 : 4.7\%\text{)}
\]

Where \( Y = \) Commodity Price, dependent variable

\( X_1 = \) Open Interest \quad \text{and} \quad U_t = \text{Sum of residuals (error terms)}
5.2. After the financial crisis in 2008

5.2.1. The causality between BDI and seaborne trade volume

1) Unit Root Test and Correlation

As result of the Unit Root Test to investigate stationary of variables, seven variables including BDI were used to test the stationary of data in the model. Even though trade volume of grain showed the state of being stationary, coal, dead weight and industrial production revealed relatively strong correlation between BDI with the coefficient of 0.29, 0.21 and -0.20 respectively.

It is difficult to argue that there was a statistically significant correlation between BDI and sea borne trade volume. Thus, this dissertation did not continue to progress to the next tests because it is difficult to see if BDI is correlated with trade volume of cargo in terms of the criteria for the assessment of correlation coefficient.

Table 12: Coefficient between BDI and trade volume

<table>
<thead>
<tr>
<th></th>
<th>BDI</th>
<th>Iron Ore</th>
<th>Coal</th>
<th>Crude Oil</th>
<th>Grain</th>
<th>Industrial Production</th>
<th>Dead Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>1</td>
<td>0.176</td>
<td><strong>0.292</strong></td>
<td>-0.073</td>
<td>-0.083</td>
<td><strong>0.213</strong></td>
<td><strong>0.202</strong></td>
</tr>
<tr>
<td>Iron Ore</td>
<td>0.176</td>
<td>1</td>
<td>0.697</td>
<td>-0.254</td>
<td>0.155</td>
<td>0.217</td>
<td>-0.177</td>
</tr>
<tr>
<td>Coal</td>
<td><strong>0.292</strong></td>
<td>0.697</td>
<td>1</td>
<td>-0.144</td>
<td>0.047</td>
<td>0.239</td>
<td>-0.253</td>
</tr>
<tr>
<td>Crude</td>
<td>-0.073</td>
<td>-0.254</td>
<td>-0.144</td>
<td>1</td>
<td>-0.105</td>
<td>0.029</td>
<td>0.011</td>
</tr>
<tr>
<td>Grain</td>
<td>-0.083</td>
<td>0.155</td>
<td>0.047</td>
<td>-0.105</td>
<td>1</td>
<td>-0.001</td>
<td>0.072</td>
</tr>
<tr>
<td>Production</td>
<td><strong>0.213</strong></td>
<td>0.217</td>
<td>0.239</td>
<td>0.029</td>
<td>-0.001</td>
<td>1</td>
<td>-0.325</td>
</tr>
<tr>
<td>DWT</td>
<td><strong>0.202</strong></td>
<td>-0.177</td>
<td>-0.253</td>
<td>0.011</td>
<td>0.072</td>
<td>-0.325</td>
<td>1</td>
</tr>
</tbody>
</table>
5.2.2. The causality between BDI and commodity price

1) Unit Root Test

All seven variables are show in the state of non-stationary. However, all non-stationary variables were converted into stationary variables by the functions of 1st difference in Eviews. Eventually, stationary variables were input to the next process for the data analysis (Brooks, 2014).

Table 13: The initial result of Unit Root Test on commodity price

<table>
<thead>
<tr>
<th></th>
<th>Augmented Dickey-Fuller&lt;sup&gt;32&lt;/sup&gt;</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T-stat</td>
<td>5% Cr.value</td>
</tr>
<tr>
<td>BDI</td>
<td>-2.162</td>
<td>-2.903</td>
</tr>
<tr>
<td>Iron Ore</td>
<td>-1.353</td>
<td>-2.903</td>
</tr>
<tr>
<td>Coal</td>
<td>-1.415</td>
<td>-2.904</td>
</tr>
<tr>
<td>Crude Oil</td>
<td>-2.394</td>
<td>-2.904</td>
</tr>
<tr>
<td>Grain</td>
<td>-2.325</td>
<td>-2.904</td>
</tr>
<tr>
<td>Production</td>
<td>-1.874</td>
<td>-2.904</td>
</tr>
<tr>
<td>DWT</td>
<td>-2.190</td>
<td>-2.911</td>
</tr>
</tbody>
</table>

2) Correlation

The price of crude oil has relatively high correlation with BDI in terms of correlation coefficient 0.22 and correlation between explanatory variables; iron ore and coal with coefficient 0.86, iron ore and dead weight with a coefficient of 0.54. Comparing with the case of before crisis, it is difficult to find a difference in correlation between before and after crisis.

<sup>32</sup> It is one of test ways invented by Dickey and Fuller in 1981 to investigate data stationarity
Table 14: Coefficient between BDI and commodity price

<table>
<thead>
<tr>
<th></th>
<th>BDI</th>
<th>Iron Ore</th>
<th>Coal</th>
<th>Crude Oil</th>
<th>Grain</th>
<th>Industrial Production</th>
<th>DWT</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI</td>
<td>1</td>
<td>-0.093</td>
<td>-0.181</td>
<td>0.223</td>
<td>0.048</td>
<td>0.078</td>
<td>0.113</td>
</tr>
<tr>
<td>Iron</td>
<td>-0.093</td>
<td>1</td>
<td><strong>0.861</strong></td>
<td>0.028</td>
<td>0.007</td>
<td>-0.049</td>
<td><strong>0.545</strong></td>
</tr>
<tr>
<td>Coal</td>
<td>-0.181</td>
<td><strong>0.861</strong></td>
<td>1</td>
<td>0.060</td>
<td>0.038</td>
<td>-0.051</td>
<td>0.584</td>
</tr>
<tr>
<td>Crude</td>
<td><strong>0.223</strong></td>
<td>0.028</td>
<td>0.060</td>
<td>1</td>
<td>0.248</td>
<td>-0.002</td>
<td>0.138</td>
</tr>
<tr>
<td>Grain</td>
<td>0.048</td>
<td>0.007</td>
<td>0.038</td>
<td>0.248</td>
<td>1</td>
<td>-0.251</td>
<td>0.327</td>
</tr>
<tr>
<td>Production</td>
<td>0.078</td>
<td>-0.049</td>
<td>-0.051</td>
<td>-0.002</td>
<td>-0.251</td>
<td>1</td>
<td>-0.325</td>
</tr>
<tr>
<td>DWT</td>
<td>0.113</td>
<td><strong>0.545</strong></td>
<td>0.584</td>
<td>0.138</td>
<td>0.327</td>
<td>-0.325</td>
<td>1</td>
</tr>
</tbody>
</table>

3) T-Test for significance of model

Through the T-test for all variables and T-test for significant variable, the price of coal, price of iron ore and dead weight were extracted as significant variables. It indicates that the probability of three variables is less than the significance level of 0.05.

In addition, adjusted $R^2$ 0.10 means that the change of explanatory variables in this model has 10% of explainable power to the change of dependent variable BDI. It means that after the crisis, BDI has tendency to be affected by other factors instead of commodity price changes.

Table 15: T-Test for significant variables
<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>Std Error</th>
<th>T-Statistic</th>
<th>Prob</th>
<th>Adjusted R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>8,121.467</td>
<td>2,475.485</td>
<td>3.280</td>
<td>0.001</td>
<td>0.109</td>
</tr>
<tr>
<td>Coal Price⁹³</td>
<td>-1,570.229</td>
<td>588.923</td>
<td>-2.666</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Crude Oil Price</td>
<td>2,721.004</td>
<td>1,522.495</td>
<td>1.787</td>
<td>0.078</td>
<td></td>
</tr>
<tr>
<td>DWT</td>
<td>108.598</td>
<td>50.356</td>
<td>2.156</td>
<td>0.034</td>
<td></td>
</tr>
</tbody>
</table>

4) Investigating violations of the assumptions of the CLRM

In this case, there is no significant change in the testing violations of the assumptions of the CLRM. That is, the model has statistically satisfied the CLRM’s assumptions; Homoscedasticity and Stability. **In case of Serial correlation test, the model was corrected by Newey West in order to eliminate Serial correlation** (West, 1987).

Table 16: *Investigating violations of the assumptions of the CLRM*

<table>
<thead>
<tr>
<th></th>
<th>F-Statistic</th>
<th>Prob</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteroscedasticity</td>
<td>1.5881</td>
<td>0.1389</td>
<td>Prob. F(9,61)</td>
</tr>
<tr>
<td>Serial Correlation</td>
<td>17.4102</td>
<td>0.0000</td>
<td>Prob. F(10, 57), Corrected by Newey West</td>
</tr>
<tr>
<td>Stability Ramsey</td>
<td>0.3668</td>
<td>0.5468</td>
<td>Prob. F(1, 66)</td>
</tr>
</tbody>
</table>

³³ All commodities price using in the model came from physical spot market published by The World Bank
5) Final Formulas

Comparing with before the crisis, explanatory variables’ absolute scale of influence on BDI remained $1\%^{34}$ of scale before the crisis. It is a crucial point to infer the reason for the collapse of BDI in 2008. At that time, BDI experienced a drastic decline within seven months from 11,793 points to 663 points.

\[
Y_t = \beta_0 + \beta_1 \cdot X_1 + \beta_2 \cdot X_2 + \beta_3 \cdot X_3 + \beta_4 \cdot X_4 + U_t \quad \text{Equation (2)}
\]

\[
Y_t = 8,121.4 - 1,570.22 \cdot X_1 - 2,721 \cdot X_2 + 108.59 \cdot X_3 + U_t \quad \text{(Adjusted } R^2: 10.9\% \text{ )}
\]

Where $Y = \text{BDI}$, the dependent variable

$X_1 = \text{Coal Price}, \quad X_2 = \text{Crude Oil}, \quad X_3 = \text{Dead Weight},$

\[U_t = \text{Sum of residuals (error terms)}\]

---

5.2.3. The causality between commodity price and financial market

1) Unit Root Test

All non-stationary variables were converted into stationary variables by the functions of 1st difference in Eviews. Eventually, stationary variables were input to the next process for the data analysis (Brooks, 2014).

Table 17: The initial result of Unit Root Test on financial market

<table>
<thead>
<tr>
<th>Augmented Dickey-Fuller</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>T-stat</td>
<td>5% Cr. value</td>
</tr>
</tbody>
</table>

$^{34} 1\% = \Sigma(\text{absolute value of coefficients after crisis excluding constant}) / \Sigma(\text{absolute value of coefficients before crisis excluding constant})$
2) Correlation

Comparing with the case of before the crisis, the coefficient between Open Interest and Net Futures Position decreased from 0.15 to (-)0.04 and the coefficient between Commodity Price and Net Futures Position sharply increased from 0.02 to 0.49.

The coefficient between Commodity Price and Open Interest shrank relatively from 0.16 to 0.02. Through the analysis of these changes, it can be inferred that the future market influence on physical commodity prices has increased after the financial crisis in 2008.

Table 18: Coefficient between commodity price and financial market

<table>
<thead>
<tr>
<th></th>
<th>Commodity Price</th>
<th>Net Futures Position</th>
<th>Open interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commodity Price</td>
<td>1</td>
<td>0.495</td>
<td>0.027</td>
</tr>
<tr>
<td>Net Futures Position</td>
<td>0.495</td>
<td>1</td>
<td>-0.049</td>
</tr>
<tr>
<td>Open-interest</td>
<td>0.027</td>
<td>-0.049</td>
<td>1</td>
</tr>
</tbody>
</table>

3) T-Tests for significance of model

Such changes in correlation between commodity prices and future markets can be demonstrated by the estimated model because the explainable power of the estimated model after the crisis increased enormously from 4.7% to 17% since the financial crisis.
Table 19: *T-Test for significant variables*

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>Std Error</th>
<th>T-Statistic</th>
<th>Prob</th>
<th>Adjusted $R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>-11.80233</td>
<td>4.154996</td>
<td>-2.84051</td>
<td>0.0059</td>
<td>0.17</td>
</tr>
<tr>
<td>Net Futures position</td>
<td>1.421358</td>
<td>0.349240</td>
<td>4.069857</td>
<td>0.0001</td>
<td></td>
</tr>
</tbody>
</table>

4) Investigating violations of the assumptions of the CLRM

To verify the goodness of the estimated model as mentioned before, this dissertation undertook detecting Heteroscedasticity, Serial correlation and Stability test for the model in order as follows. According to the following results, this dissertation confirmed that the model has statistically satisfied the CLRM’s assumptions; Homoscedasticity and Stability. **In case of Serial correlation test, the model was corrected by Newey West in order to eliminate Serial correlation** (West, 1987).

Table 20: *Investigating violations of the assumptions of the CLRM*

<table>
<thead>
<tr>
<th></th>
<th>F-Statistic</th>
<th>Prob</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heteroscedasticity</td>
<td>1.0113</td>
<td>0.3690</td>
<td>Prob. F(2,69)</td>
</tr>
<tr>
<td>Serial Correlation</td>
<td>19.6903</td>
<td>0.0000</td>
<td>Prob. F(10, 60), <strong>Corrected by Newey West</strong></td>
</tr>
<tr>
<td>Stability Ramsey</td>
<td>1.1719</td>
<td>0.2828</td>
<td>Prob. F(1, 69)</td>
</tr>
</tbody>
</table>
5) Final Formulas

The explanatory power of this formula increased sharply to the level of 17.9% compared with before the crisis of 4.7%. Especially, it means that commodity price dependency on future markets has increased after the financial crisis.

\[
Y_t = \beta_0 + \beta_1 \cdot X_1 + U_t \quad \text{Equation ③}
\]

\[
Y_t = -11.8023 + 1.4213 \cdot X_1 + U_t
\]

(Adjusted R\(^2\): 17.9%)

Where \( Y \) = Commodity Price, dependent variable

\( X_1 \) = Net Futures Position \quad \( U_t \) = Sum of residuals (error terms)
6. Conclusion and The necessity of further research

6.1. Conclusion

In view of the collapse of the BDI in 2008, this dissertation has raised the question whether the prevailing belief that BDI is well reflected, the physical market and derivative market conditions are still valid. To answer this question, through the literature review, this dissertation affirmed that demand on the shipping industry is derived from global transport demand and shipping is a demand-driven market.

Moreover, ship supply in short-term is inelastic against demand on shipping because the shipping industry is a capital intensive industry. Through the empirical analysis on data containing market information, this dissertation established three hypotheses to verify the reasons for the collapse of BDI in 2008 and infer these reasons with assessment of hypotheses.

1) Firstly, regarding the question: Does the BDI have correlation and causality with seaborne trade volume? According to the result of the empirical tests on the correlation between BDI and seaborne trade volume throughout before and post crisis in 2008, this dissertation affirmed that the coefficient between two the post crisis is around 0.2, which is larger than the number before the crisis with around 0.1.

However, it is practically difficult to continue on the next process, making the regression model, due to highly non-stationary problems in inputting variables and low correlation between dependent and independent variables. It means that the
insignificant level of correlation between BDI and seaborne trade volume is not able to satisfy one of the prerequisite conditions for the causality test. Thus, this dissertation suggested that at least there was no statistically significant correlation and causality between BDI and seaborne trade volume.

2) Secondly, as to the question: Is there causality between BDI and the physical-based commodity market price?

Given that the shape of demand and supply curve of the freight rate market are close to the vertical shape after the section of high freight rate, the freight rate elasticity of supply on ship commitment (ΔF/ΔS) is highly elastic as seen in Figure 17. It means that the change of freight rate sensitively corresponds to the fluctuation of ship commitment in the freight market.

![Figure 17: Equilibrium in freight market](image)

(Source: Reorganized by the author based on Maritime Economics of Martin Stopford in 2009)
One the other hand, as can be seen in Table 21, 94%\textsuperscript{35} of BDI fluctuation can be explained by the change of supply of ship commitment before the crisis. Accordingly, the supply of ship commitment instead of variables related with commodity price was considered as the most influential variable in the change of BDI during before crisis.

Table 21: \textit{Statistical value between BDI and commodity price}

<table>
<thead>
<tr>
<th>Absolute value of Coefficient</th>
<th>Before Crisis(A)</th>
<th>After Crisis(B)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient</td>
<td>Ratio</td>
</tr>
<tr>
<td>Supply</td>
<td>408,360</td>
<td>94%</td>
</tr>
<tr>
<td>Demand</td>
<td>25,192</td>
<td>6%</td>
</tr>
<tr>
<td>Total</td>
<td>433,551</td>
<td>100%</td>
</tr>
</tbody>
</table>

In addition, taking into consideration that the monthly based ship commitment change rate increased from January 2004 until September 2008 with an average change rate of around 0.5\% in Figure 15, it implied that ship commitment increased steadily from January 2004 in the long term, even if the ship commitment increased in short term. Eventually, these changes incurred the shift of supply curve to the right direction in the short term.

As a result, the nature of demand and supply curve of freight market and the increase of ship commitment in short term were considered as the main reasons for the sharp decline of BDI in 2008.

3) Thirdly, the Correlation Coefficient and the Explainable Power of the Model ($R^2$) between the two increased sharply with an increasing rate of 192\% and 280\%, respectively. It was inferred by the change of coefficient between variables in each period.

\textsuperscript{35} 94 \% = \frac{\text{Absolute value of coefficient of supply}}{\text{Total absolute value of coefficients}}
For instance, this dissertation identified that at the time of pre-crisis, the correlation coefficient between commodity price and Open-Interest is larger than the coefficient of Commodity Price and Future Net Position.

However, the opposite phenomenon occurred after the crisis as seen in Table 22. It can be considered that such internal position change between Open-Interest and Futures Net Position in the financial market lead to the increase of connectivity between the financial market and the physical commodity market after the crisis. Moreover, the influence by the financial market against the physical commodity market has increased passing the financial crisis.

Table 22: Statistical value between commodity price and financial market

<table>
<thead>
<tr>
<th></th>
<th>Before Crisis(A)</th>
<th>After Crisis(B)</th>
<th>Change (B/A-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correlation Coefficient</td>
<td>16.9</td>
<td><strong>49.5</strong></td>
<td><strong>192%</strong></td>
</tr>
<tr>
<td>Explainable Power of Model(R²)</td>
<td>4.7</td>
<td><strong>17.9</strong></td>
<td><strong>280%</strong></td>
</tr>
<tr>
<td>Commodity Price-Open Interest</td>
<td>0.169</td>
<td>0.027</td>
<td><strong>-84%</strong></td>
</tr>
<tr>
<td>Commodity Price-Futures Position</td>
<td>0.027</td>
<td><strong>0.495</strong></td>
<td><strong>1,733%</strong></td>
</tr>
</tbody>
</table>

To sum up, in view of the above comprehensive perspective of correlation and causality analysis, the reason for the collapse of BDI in 2008 can be identified as follows.

To begin with, the change in sea borne trade volume cannot be regarded as a reason for the collapse of BDI because the correlation between BDI and sea borne trade volume was not verified by its coefficient. Simultaneously, there is no reason for being the causality between the two without significant level of correlation.

In terms of the causality between the physical commodity market price and the collapse of BDI, the increase of monthly based ship commitment in the market, and
the freight rate elasticity of supply on ship commitment ($\Delta F/\Delta S$) derived from the nature of the demand and supply curve of the freight market were considered as one of the main reasons for the collapse of BDI in 2008.

Finally, even though, it is difficult to find evidence that the change of physical commodity market prices can be considered as the reason for the collapse of BDI in 2008, this dissertation affirmed that the phenomenon of financialisation\(^{36}\) of the physical commodity market has progressed passing the financial crisis in 2008 through the analysis of the correlation between the two and the change of explainable power of the estimated model.

### 6.2. The necessity of further research

1) With regard to the demand and supply curve of the freight market, this dissertation did not analyze the previous research on the shape of curves and degree of inclines because verifying the previous results of demand and supply curves of the freight market is out of the scope of this dissertation.

2) Regarding the circumstance of just before crisis, this dissertation recognized that there are limitations to verify where the freight market equilibrium is. That is, as mentioned in Figure 6 (Shipping supply curve), it is difficult to realize where the freight market equilibrium is. In fact, it is out of the scope of this dissertation.

3) Regarding the issue of financialization in the commodity market, this dissertation was faced with the practical limitation for the reclassifying commercial trading and non-commercial trading. That is, according to the data from CFTC, they regarded

\(^{36}\)Financialization: it indicates that the increasing role of financial motives, financial markets and financial actors in the operation of commodity markets (UNCTAD, 2011)
transactions in the futures market by the Pension Fund, Insurance Companies and Swap-Dealer\textsuperscript{37} as commercial trading (CFTC, 2009).

Therefore, it is difficult to secure raw data relating with future trading to detect the magnitude of financialization in the commodity market by non-commercial investors\textsuperscript{38} and find causality between futures and commodity market.

4) Financial asset portfolio in the financial market was entirely determined by financial market investors. It indicates that the financial market is affected by the behaviour of financial market participants. For instance, information on general economic activities, the private needs on changing asset portfolio and investors’ expectation on market prospect can lead to the change of the financial market conditions.

Therefore, expecting behaviour of market participants is close to being unfeasible work and data analysis using econometric model is not a simple work. In fact, financial information relating with decision making on asset portfolio lies in the private sectors.

Thus, it is very complicated work to analyze the behaviour of financial market participants and to access into financial market information. Despite of the current limitation, market risks can be analyzed and measured by more advanced theory and empirical test methods through the development of econometric theories and the combination between econometric theory and behavioral science.

\textsuperscript{37} Swap Dealer: An individual who acts as the counterparty in a swap agreement for a fee called a spread. Swap dealers are the market makers for the swap market (Investopedia .com)

\textsuperscript{38} Non-commercial investors: they have no attention to trading the physical based commodities and they have attention only making profit through the index investment or arbitrage trading in the financial market.
References

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Lee, S. M. (2011). *A study on the change of determinants on freight fluctuations in*


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