LUND UNIVERSITY

Faculty of Engineering
Division of Engineering Logistics

Lantmännen

Forecasting model for dry bulk sea freight

Authors: Joel Odland
Frans Kaltea

Supervisors: Lars Seppä, Lantmännen
Johan Lundin, Lund University, Faculty of Engineering, Division of Engineering Logistics

Preface

This thesis was conducted during the autumn of 2010 and is the concluding part of our Master of Science in Industrial Engineering and Management at the Faculty of Engineering, Lund University, Sweden. The thesis was made in corporation with Lantmännen, as well with support from the Division of Engineering Logistics.

We would like to extend our thanks to all of you who have helped us made this thesis possible. First of all, special thanks to our supervisor and friend Johan Lundin for all your advice and support. Secondly we wish to thank all people at Lantmännen; our supervisor Lars Seppä, Ingemar Steneholm and Erika Bjurling for assisting with time, knowledge and data.

Also, many thanks to friends and family who have supported us through the process of completing this master thesis.

Lund, January 2011

Joel Odland | Frans Kaltea

Abstract

Title: Forecasting model for dry bulk sea freight

Authors: Frans Kaltea, Joel Odland

Presentation Date: 21st of January, 2011

Division: Engineering Logistics, Faculty of Engineering, Lund University

Supervisors: Johan Lundin (LTH), Lars Seppä (Lantmännen)

Key Words: Dry bulk sea freight, freight rate, forecasting model

Background: Lantmännen want to better understand what is affecting the freight rates for sea transportation, offered to them by shipowners and shipbrokers. In order to help them with that, an understanding of how the rates are constructed is needed. The initial approach was that the freight rates are built on two main factors. The first factor being the actual cost that the shipping will inflict, on the shipowners, and the second factor the market situation (the demand versus the supply of ships).

Purpose: The main purpose of this thesis is to provide Lantmännen with information, that help them make better decisions when procuring sea freight services. This purpose is fulfilled specifically by the development of a price forecasting model. A secondary objective is to develop a process and methodology for developing price indices and forecasting models.

Methodology: The study is conducted with an abductive approach, with an initial focus on broad qualitative data collection, followed by a deep quantitative analysis and development of a the forecasting model. The qualitative step involved literature research and interviews performed with Lantmännen, shipowners and shipbrokers. The quantitative step contained regression analysis as the foundation of the model building, and later accuracy tests of potential models, including both residual and forecasting ability analyses.

Data collection: In the data collecting step industry and expert knowledge about the shipping industry was collected through interviews and literature review. This resulted in a collection of cost factors and demand/supply factors, affecting the northern European market of dry bulk sea freight. In the following step of the process these factors were used to create a cost model and a demand & supply model.

Model Development: The cost model was constructed based on the result from the qualitative data collection. The model was able to calculate the actual costs for any ship on every route used by Lantmännen, hence the profit for each ship, route and time period could be calculated by subtracting the calculated costs from the stipulated freight rate. This profit was calculated for each shipment made by Lantmännen between January 2008 and November 2010 and the average profit for each month was calculated and used as the time series representing the market situation during this time period.

The demand & supply model is a regression model constructed to accurately model the above mentioned market situation time series. The suitable regression model was decided by the usage of a combination of a mathematical algorithms and logical tests. Where the former verified that the model did not contradict the theoretical relations between factors and the market situation found during the qualitative data collection, e.g. increased commodity prices should have the effect of increasing the freight rates. The demand & supply model was built with five different indices as underlying components.

When a suitable model for the supply & demand (market situation) was created it was merged together with the cost model to create the final forecasting model that was to be used by Lantmännen. The Forecasting Model was designed to give forecasts of the freight rate for the two time horizons of 3 and 6 months for the two separate routes of export and import shipments to Sweden. The forecasting tool gives an overall price forecast in percent, but also a price interval for certain example routes.

Conclusions: The forecasting model was developed and tested with good results and if Lantmännen uses the model as intended they will acquire new knowledge that will help them make better decisions when purchasing sea freight services. That the second purpose, to develop a process for the creation of forecast models, is fulfilled was apparent since the method that was used to structurally develop this model was successful. Even though the process developed in this thesis showed good results, it might not be possible to apply to all situations. This since the structure for the model, were freight rates are divided upon costs and a demand and supply effect, was based upon findings about the nature of the dry bulk sea freight market. The process should however be valid for developing price indices for those markets where there generally is a low differentiation in offered products or services.

Definitions and abbreviation

Bunker: The collective name of fuel oils used to power ship engines.

Canal: A maritime waterway, either artificially constructed or an improved river, used by ships. There is generally a fee, canal fee, associated with travelling on a canal.

CIF: Short for: cost, insurance, freight. A type of standard agreement contract called incoterm that is used when transporting goods. When using a CIF contract, the seller pays for the transportation and insurance all the way to the buyers port of choice.

Confidence Interval: An interval showing the reliability of an estimate. A large interval indicates a lower reliability than a small interval. The confidence interval is normally constructed for a specific *confidence level*, which approximately equals the probability of the estimated parameter to be contained within the interval.

Covariance: A statistical measure of how much two variables change together. A large covariance, compared to a smaller, indicates that the variables, to a large extent, are changing direction simultaneously.

Deadweight tons (DWT): The weight a ship can carry when loaded to its marks, including cargo, fuel, fresh water, stores and crew.

Demurrage: The charge (per day) a freight purchaser needs to pay to the shipowner when the ship is used more than stipulated in the contract, e.g. when the loading is delayed.

Dry Bulk: Cargo that is transported unpackaged and in large quantities often in bulk carrier ships, railroad cars or tanker trucks. Examples of dry bulk are: coal, grain, iron ore, wood chips, scrap metal, sand and gravel.

Fairway (maritime fairway): a road in the water that is marked by various signs. It is not unusual that ships have to pay fairway dues when traveling on fairways.

FOB: Short for: free on board. A type of standard agreement contract called incoterm that is used when transporting goods. When using a FOB contract the seller arranges the transportation only to the origin port, and it is the buyers responsibility to arrange and pay for the sea freight.

Forecast: A statement about events in the future whose actually outcomes have not yet been observed. Forecasts are used in several different processes within a company, e.g. when planning the production capacity and when doing budgets.

Freight purchasers: Companies that purchases ship freight for their goods.

Future contract: A contract agreed between the freight purchaser and the shipowner, to ship a specified amount at a future date for a price agreed today.

Gross Tonnage (GT): Measurement of the ship's internal open volume, based on the IMO Tonnage Convention.

Index/Indices: A time series of values indicating the development of the underlying data. The underlying data can be anything that can be measured. An Index can be interpreted as an variable that is varying over time.

Just In Time (JIT): An inventory strategy that focuses on keeping low inventories and an efficient production process. Input goods are normally delivered at the production facility in the exact quantities that is needed and as close to the date when the production starts as possible.

NS3: Short for North-South 3 Month regression model.

NS6: Short for North-South 6 Month regression model.

Sea freight: The method of transporting goods from one point to another by the use of a ship.

Ship: In this report this refers to dry bulk carriers in the range of 400 to 10 000 DWT, in other literature sometimes called short sea vessels, general cargo ship and/or coasters.

Shipowner: A company that own one or more ships. These companies are responsible for the technical and commercial management of their ships (unless these services has been outsourced to a third party).

Shipbroker: A company, or a person working for a shipbroking company, that has the role of a middleman arranging deals between shipowners and sea freight purchasers. Shipbrokers charge a percentage commission on the freight rate, when fixing a ship to a specific freight.

SN3: Short for South-North 3 Month regression model.

SN6: Short for South-North 6 Month regression model.

Spot market: A financial market where financial instruments or commodities are traded for immediate delivery. I.e. a transport bought on the spot market will be carried out within the nearest future.

Tons: Metric ton, equivalent to 1000 kilogram.

Transportation modes: Different alternative transportation methods, e.g. transportation by ship, truck, train or airplane.

Variable: A value that might change, either within the scope of a given problem or over time.

Contents

1 Introduction

This first introducing chapter will provide the background to the thesis, and describe the problem associated to this background that the master thesis will address. Furthermore the purpose, focus and expected results will be discussed. The chapter will also provide a deposition that briefly presents each chapter in this master thesis report.

1.1 Background

In an increasingly global world with increasing trade and competition amongst companies, it has become important to have an efficient and effective supply chain in order to be successful. Dr. Douglas M. Lambert put it like this:

> "One of the most significant paradigm shifts of modern business management is that individual businesses no longer compete as solely autonomous entities, but rather within supply chains. In this emerging competitive environment, the ultimate success of the business will depend on management's ability to integrate the company's intricate network of business relationships. The members of The Global Supply Chain Forum refer to the management of this network of relationships as supply chain management."[1]

An important part of supply chain management is purchasing. Purchasing can be defined as:

> "The management of the company's external resources in such a way that the supply of all goods, services, capabilities and knowledge which are necessary for running, maintaining and managing the company's primary and support activities is secured at the most favorable conditions."[2]

Since the overall business trend is to outsource non-core business, purchasers now have to procure the parts of the business that were outsourced. It is often part of the purchaser's strategic role to evaluate whether to do certain activities in-house or purchase from a third party. In order to be successful, purchasers must have good knowledge of what the price of a product or service should be, what factors that affect the price and what the price might be in the future.[3]

Transportation is a typical service that is purchased, and there are in general four types of transportation modes: road, air, sea and rail. Those have different characteristics in terms of cost, capital tied, delivery service and shipment size. What mode to use has to be evaluated with a holistic approach, were the different characteristics of the modes are considered. One tool that purchasers can use when procuring transports are indices, which indicate the market price for a transport of a standard volume (such as a container or a ton) and of a specific time or length (often as a route). If there are no indices available, the purchasers often has to calculate

[1] (Lambert, 2008)
[2] (van Weele, 2005)
[3] (van Weele, 2005)

the actual cost of the transportation service himself. The price will then be the sum of this estimated cost and the selling company's profit margin.[4]

The characteristics of sea freight are low cost, high amount of capital tied, low delivery service level and large shipment sizes. For transport of bulk goods such as ore, coal, cement or grain those characteristics are a good fit. Bulk goods are generally of low value, do not tie much capital and the service level is often of little importance. It is suitable to send large order quantities over long distances, were the goods do not need to be packed in boxes, containers or equivalent. Today, there are no realistic substitutes to sea freight for large quantities of bulk goods.

There are a number of different types of ships, with different constructions, that are specialized in different types of goods. For shipping of dry bulk, there are mainly two types of ships that are interesting: deep-sea dry bulk carriers, for larger quantities between continents, and costal trading vessels for smaller quantities or when access to shallower water is needed. It is also possible to ship dry bulk on so called general cargo carriers. The sizes of all those ships are measured in deadweight tonnage (DWT), which is a measure of how much weight a ship can carry in tons. The size of dry bulk ships ranges from a couple of hundred deadweight tons up to 400 000 deadweight tons for the largest Capesize bulk carriers. The smallest ships to have an appropriate index have deadweights of more than 10 000 tons. On the Baltic Exchange, one of the most used sources for freight market prices, the index for the smallest dry bulk ships are the Baltic Exchange Handysize Index, where the ships have a deadweight of approximately 28 000 tons.[5]

The lack of an appropriate index for smaller ships pose a problem for companies in need of freight of less than 10 000 ton of dry bulk per shipment. The problem is that it is hard for purchasers to acquire the knowledge and information that they need for securing freight services at *the most favorable conditions*. Lantmännen has identified these issues and they see an opportunity to gain benefits by increasing their knowledge about sea freight with dry bulk ships.

Lantmännen is one of Nordic's largest companies within food, energy, machinery and agriculture. The company has global operations, although with a strong focus on Scandinavia and Germany. The company is engaged in business activities throughout the whole value chain: "from field to fork". Lantmännen also owns several brands in the FMCG (Fast Moving Consumer Goods) sector, but are also holding the role of supplier to other industries. This broad base of business creates a strong need for coordination within the supply chain.[6]

For Lantmännen, sea freight is the second most used transportation method after road transport. The sea freight is purchased primarily through 10-15 shipbrokers, but also in some cases through direct contact with shipowners. Lantmännen purchases, approximately, 1300 separate ship freights yearly, with an average load of 1700 ton per ship. The capacity of ships

[4] (van Weele, 2005)
[5] (Baltic Exchange Information Services Ltd)
[6] (Lantmännen, 2010h)

being used ranges from approximately 300 DWT up to Panamaxsize (50 000 - 60 000 DWT), but over 90 percent of ships used are smaller than 3 000 DWT. On average Lantmännen yearly transports 2.8 million tons by sea freight. The freight of mentioned volumes is mainly shipped on dry bulk ships, and the cargo primarily consist of grain and input goods to feedstuff production.[7]

Lantmännen want to better understand what is affecting the freight rates, for sea transports, offered to them by shipowners and shipbrokers. In order to help them with that, an understanding of how the rates are constructed is needed. The initial approach is that the freight rates are built on two main factors. The first factor being the actual cost that the shipping will inflict on the shipowners and the second factor the market situation (demand vs. supply of ships).

1.2 Problem discussion

In order to purchase sea freight at *the most favorable conditions,* companies need to forecast prices of those transports. Since there are no indices or other clear indicators, it is important for the buying company to have a good way of calculating costs and estimating appropriate profit margins for the selling companies in order to forecast prices. Since the costs and appropriate profit margins are dependent on numerous factors that varies over time, such as fuel prices, cost of labor, exchange rates, interest rates and demand vs. supply of the transport services, it is a difficult task even to understand a current price. Needless to say, it is even more difficult to forecast future prices. This type of problem is applicable to all companies procuring anything.

1.3 Purpose

The main purpose of this thesis is to provide Lantmännen with information, that help them make better decisions when procuring sea freight services, by developing a price forecasting model. A secondary objective is to develop a process for developing price indices and forecasting models.

1.4 Delimitations and focus areas

The focus of the master thesis is to build a forecasting model of freight rates for transportation of dry bulk with ships in the range from 400 DWT up to 10 000 DWT, also called short sea vessels or coasters. Furthermore the focus is on sea freight between Sweden and primarily northern Europe. The historical freight rate data that is used is from Lantmännen. The motive for this focus was that this represented the majority of Lantmännen's sea freights.

Because of the limited timeframe of this project, focus will be on development and validation. The thesis will not include implementation or later tests of effectiveness and adjustments of the model.

1.5 Target group

This master thesis is aimed primarily to people involved with purchasing of sea freight at Lantmännen, at both operational, tactical and strategic level. It should also be interesting for managers at Lantmännen, whose decisions might depend on future prices of sea freight.

---

[7] (Seppä, 2010)

Secondly, the master thesis is aimed towards people with an interest in the field of logistics engineering and strategic purchasing. It is recommended that the reader have some technical and economical background as well as a basic understanding of sea freight.

1.6 Disposition

The master thesis report have the following disposition:

Chapter 1 - Introduction

The subject and the problem are introduced and the purpose of the master thesis is defined.

Chapter 2 - Company presentation

The company Lantmännen is introduced, initially on a high level, but gradually drilling down to the divisions and operations that are relevant for this master thesis.

Chapter 3 - Theoretical frame of reference

All the theories used in this master thesis are presented, everything from macroeconomics to regression analysis. This chapter is a reference, containing all theories applied and used in the subsequent processes of the thesis.

Chapter 4 - Methodology

In this chapter the methodology of the master thesis is discussed. The overall process used and the included activities are defined. The methodology chapter forms the basis of the thesis and describes how and why the research was performed in a certain way.

Chapter 5 - Step 1 – Data collection

In this chapter the results of the first step of the master thesis, the data collection, is presented.

Chapter 6 - Step 2 – Model development

The model development is discussed and the resulting models are presented, tested and verified.

Chapter 7 – Step 3 – Usability, design and evaluation of the forecasting model

The final product of the master thesis, the forecasting model, is discussed in the seventh chapter. The usability and design are discussed and presented. Finally there is an evaluation and validation of the forecasting model.

Chapter 8 - Conclusion

The last chapter contains conclusions about the overall process of this master thesis. The chapter includes discussion of whether the purpose of the project was achieved, but also suggestions to Lantmännen and to future researchers within this field of study.

2 Company presentation

In this chapter the company Lantmännen is introduced initially on a high level, but gradually drilling down to the divisions and operations that are relevant for this master thesis.

2.1 Historical background

The collaboration between Swedish farmers stretches back to second half of the 19th century when the first farmer unions were established. Those acted on a local level with the purpose to exchange experience between farmers and reduce purchase prices and transportation costs. With time, the need to establish larger trading partners became apparent and regional associations were formed. At first the associations only handled purchasing, but soon the associations also managed sales for its members.

In 1905 Svenska Lantmännens Riksförbund (The Swedish Lantmännens national associations) was founded. At the beginning seven association was included, which in 1954 had grown to 24 regional associations with a total of nearly 150 000 members. In 1971 the name Lantmännen was launched as a brand name and the Sprout symbol as logotype (see Figure 1) for Svenska Lantmännens Riksförbund and the, at the time 19, regional associations. The adaption of one common symbol that replaced 20 old ones united the associations; strengthening them individually and also provided them with a uniform appearance.[8]

Figure 1: Lantmännen Group Logotype. (Lantmännen, 2010d)

The first of January 2001, Lantmännen ek. för. (economic association) was established and all the regional associations, with exception for Kalmar Lantmän, were merged into the present group. Kalmar Lantmän decided to continue as a separate association, with a membership in Lantmännen. Most farmers are direct members in the association, but some are members through local associations.[9]

2.2 Organization & way of business

Lantmännen is a cooperative organization registered as an economic association, which is owned by approximately 37 000 Swedish farmers. It is one of the largest groups within food, energy and agriculture in Scandinavia. Lantmännen has 10 500 employees and a turnover of SEK 35,1 billion. The group's business concept is as follows:[10]

[8] (Lantmännen, 2010c)
[9] (Lantmännen, 2010e)
[10] (Lantmännen, 2010a)

"Lantmännen works closely with its customers, possessing competence, control and presence within the entire value chain - from farmland to table. With our customer in focus, we develop and process farmland resources in a responsible manner. We operate in an international market in which Sweden constitutes the foundation of our business activities."[11]

Lantmännen is active in 18 countries, with Sweden as the most important market. The primary task is to provide the members with seeds, fertilizer, plant protection and feedstuff for animals as well as receiving, storing, refining and selling what the members cultivate. Lantmännen is also involved in the energy sector with focus on bio-based energy products and environmentally adapted service products. Another business activity is sales of machinery such as tractors, equipment and threshers. Lantmännen has a matrix organization with four sectors: agriculture, machinery, energy and food, and four supporting functions: economy and finance, supply chain, human resources and communication (see Figure 2). The one division that is not represented in Figure 2 is the real estate division. It is a profit center and support unit for Lantmännen and one of the division's tasks are to manage most of Lantmännen's 300 properties.[12]

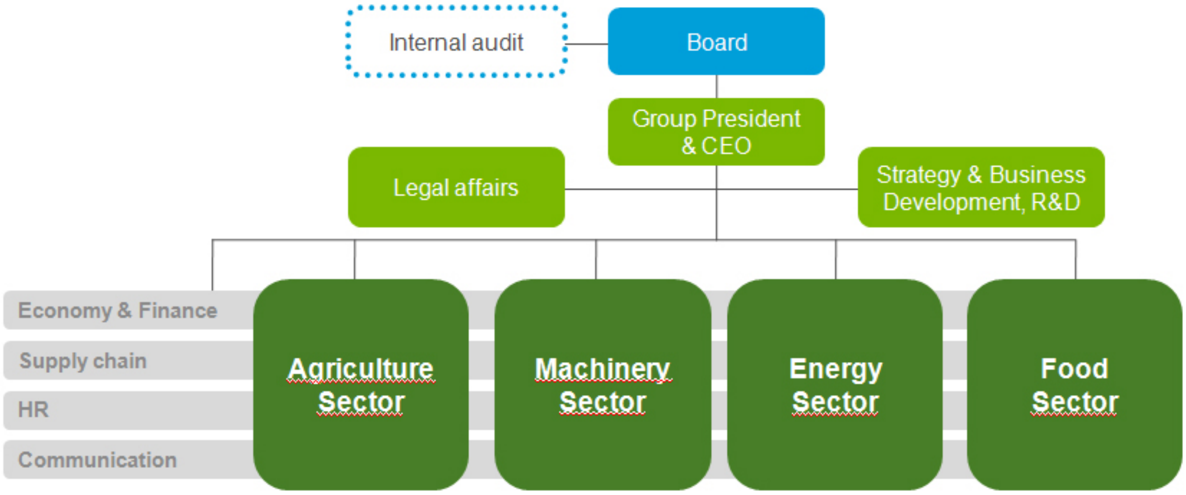


Figure 2: Lantmännen's organization. (Lantmännen, 2010f)

In order to sell all that their members cultivate Lantmännen has several channels out to the end customers. Some of the brands and the way Lantmännen is organized on a more detailed level are seen in Figure 3. A similar structure is found for the other three sectors as well.[13]

---

[11] (Lantmännen, 2010b)
[12] (Lantmännen, 2010a)
[13] (Lantmännen, 2010h)

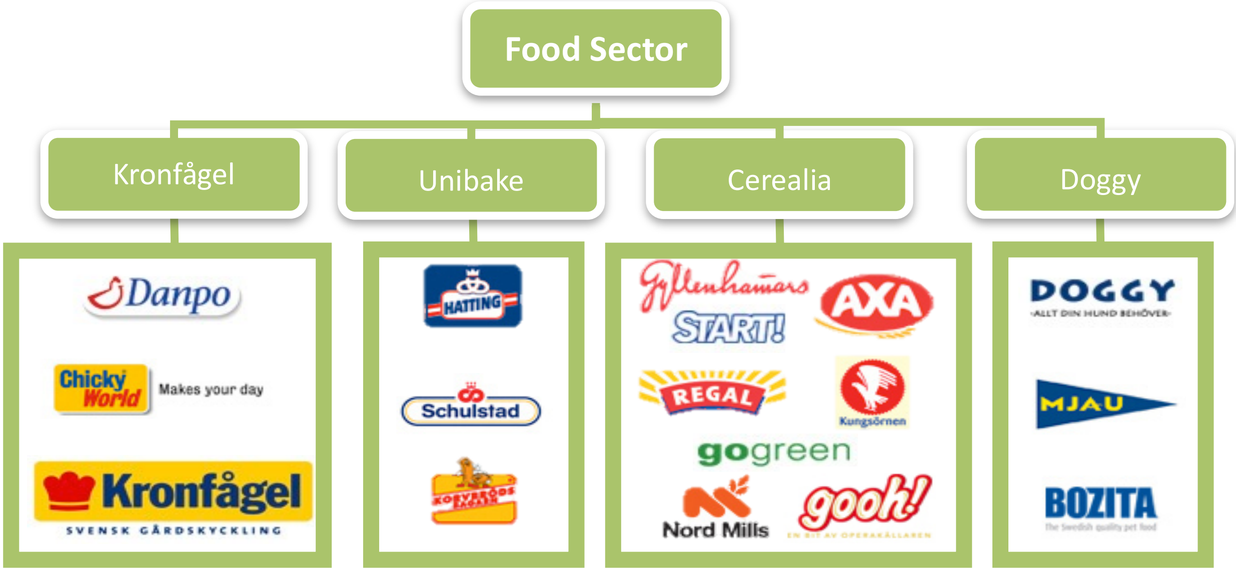


Figure 3: Some of Lantmännen's brands within the food sector.[14]

2.2.1 Parts of organization that the master thesis will focus on

The purpose of this master thesis is to help Lantmännen make better choices when purchasing sea freight. The total weight transported on sea for Lantmännen 2009 was somewhere above 2 800 000 tons. Most cargo shipped was dry bulk and the most of the dry bulk derived from the Agriculture and Food sectors (see Figure 4). The focus areas in terms of Lantmännen's organization will hence be on the Agriculture and Food sector and within the corporate function Supply chain.[15]

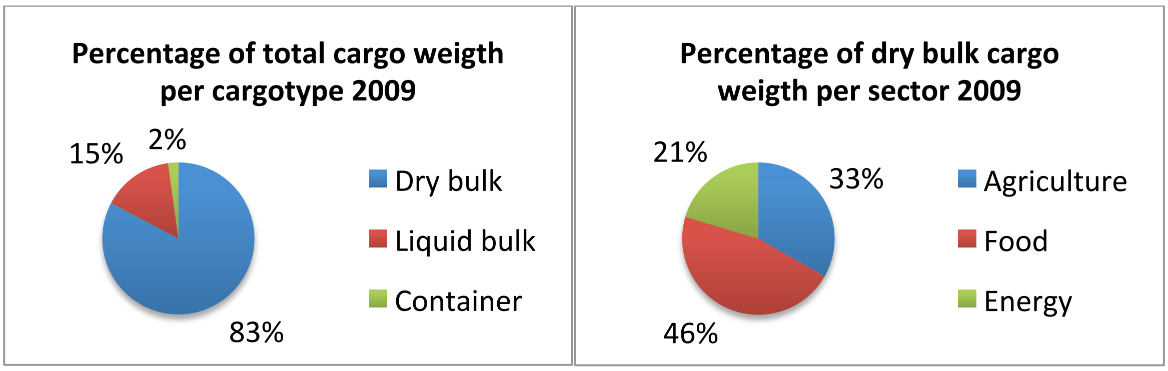


Figure 4: Total sea freight divided on cargo type (left) and dry bulk sea freight divided on sector (right).

Within the Supply chain function, that could be seen in Figure 2, Lantmännen are organized in compliance with the modes of transportation, with a special division for critical suppliers (see Figure 5). Responsible for the Sea division is Lantmännen's supervisor of this master thesis, Lars Seppä.

---

[14] All brand images are from (Lantmännen, 2010).

[15] (Seppä, 2010)

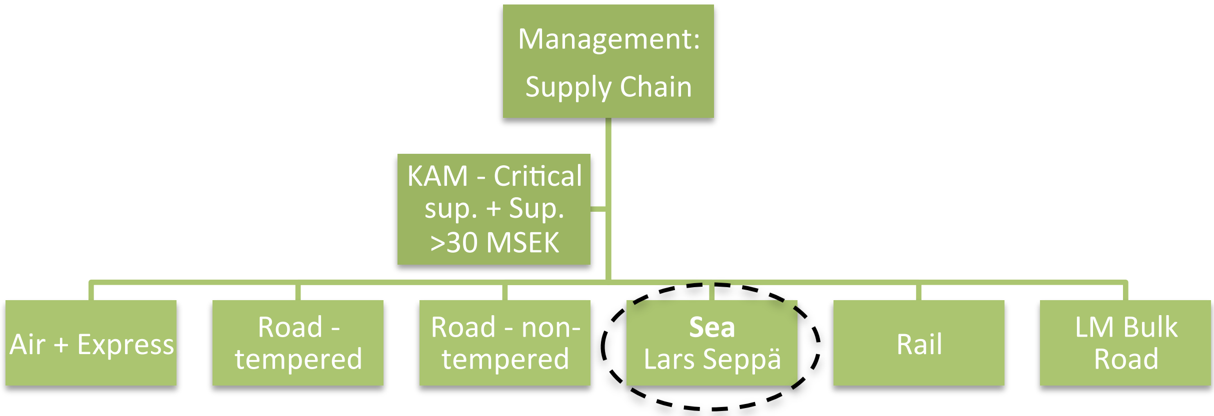


Figure 5: Organization within the supply chain function[16]

The people working within the Sea division are mainly connected to their sector. A person working with the procurement of ship services for Spannmål is mainly working under the sector Agriculture. Hence none of the freight purchasers are answering to Lars Seppä directly.

In more detail the specific areas within Lantmännen, that this thesis will focus on, are the three functions responsible for shipping grain, input goods to feedstuff manufacturing and input goods to Cerealia production in Denmark. Those three functions will, from now on, be referred to as Spannmål, Foder and Cerealia DK. One important distinction is that Spannmål and Cerealia DK transport goods in a north to south direction whereas Foder's flow of goods is in a south to north direction.[17]

[16] Modification of a figure from (Seppä, 2010).
[17] (Seppä, 2010)

3 Theoretical frame of reference

The purpose of this master thesis is to develop a price forecasting model for sea freights. In order to succeed, knowledge of how freight rates change with some underlying data is needed, and whether this data can be represented by time series or not. Three concepts that are of importance are: macroeconomics, microeconomics and supply chain management. Macroeconomics explains how global factors might affect demand and supply[18], microeconomic theory explains the relationship between demand and supply[19] and supply chain management the management of demand and supply.[20] The parts of the rates that can be explained by time series might be used to forecast future rates through regression analysis. The concepts needed are all presented in this chapter.

3.1 Macroeconomics

Macroeconomics is the study of economy-wide phenomena. For this thesis, it provides a basic framework for understanding how, and which, economy-wide factors that might affect the sea freight market. One tool for analyzing the major driving forces of change and hence the macro economical impact on an industry, or a company, is the PESTEL framework. The PESTEL framework categorizes the possible forces in six categories: political, economical, social, technological, environmental and legal (see Figure 6 for examples of forces for each category).[21]

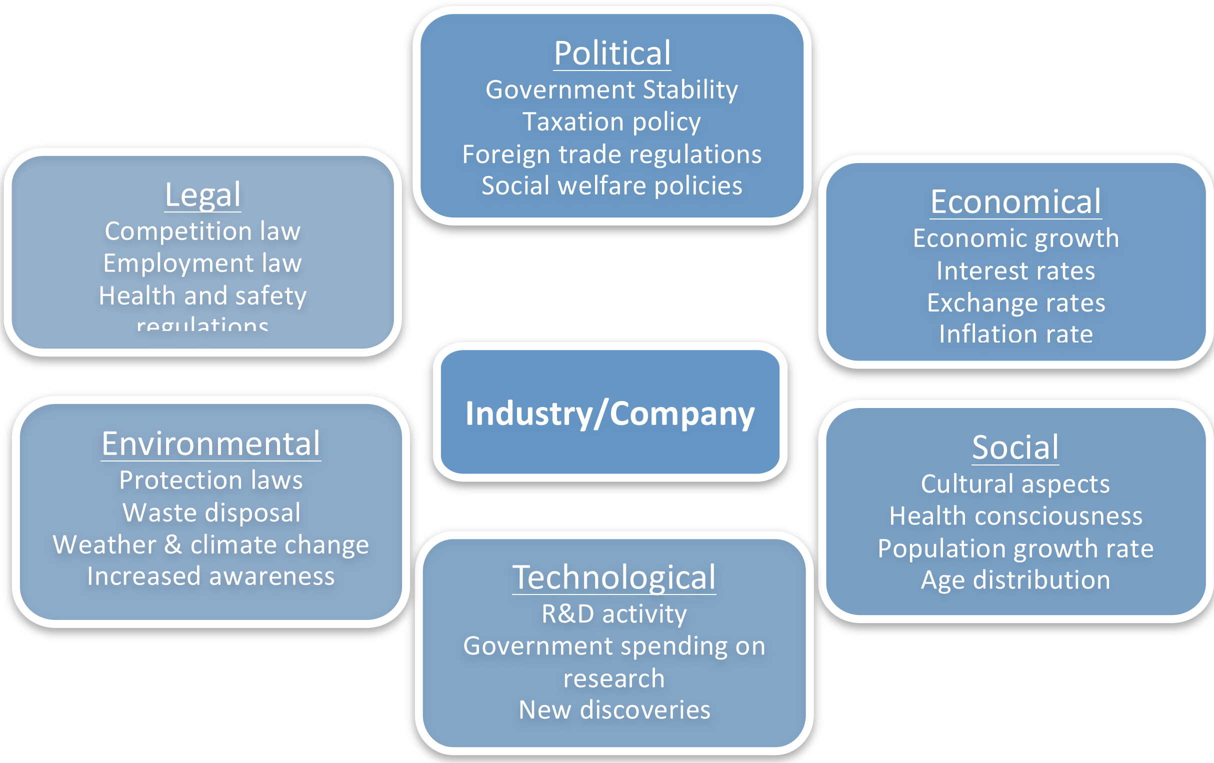


Figure 6: The PESTEL framework with some examples of driving forces (Johnson, Scholes, & Whittington, 2008)

18 (Arnold, 2008)
19 (Krugman & Wells, 2005)
20 (Chopra & Meindl, 2004)
21 (Johnson, Scholes, & Whittington, 2008)

In the PESTEL, political highlights the role of governments; economical refers to macro-economic factors such as exchange rates and business cycles; social influences include changing cultures and demographics; technological refer to innovations such as Internet or nanotechnology; environmental includes 'green' issues such as pollution and global warming; and finally legal includes legislative constraints or changes. There are likely to exist a number of factors, which might have an effect on the industry analyzed, in every category. A PESTEL analysis starts with finding possible factors that might affect the company on a macroeconomic level. Secondly, the factors are categorized into one of the six categories. The result is a categorized list of factors, from which conclusion might be drawn. A PESTEL analysis is a useful tool for understanding what might affect an industry or a company in the long run.[22]

3.2 Microeconomics

Microeconomics is a field of study that tries to analyze how firms make decisions and how they interact on a market from an economical perspective. This chapter will give a brief introduction to the concept of demand and supply and discuss a useful tool for microeconomic analyses: Porter's five forces.

3.2.1 Demand and supply

To better understand the mechanisms controlling the market of sea freight a brief explanation of demand, supply and the relationship between the two are given. The point of view will be demand and supply of the service of having goods shipped from one location to another. Demand is then the total amount of goods that purchasers of the service are willing to ship at a certain price. Supply on the other hand is the sum of goods that all shipowners are willing to ship at a certain price on a market. The market is always striving to reach equilibrium between demand and supply.

Another important concept is price elasticity. The price elasticity is a measure of how much the demand or supply will change with a change in price. If, for example, the supply of a service has low price elasticity, the supply will not decrease as much with a decrease in price as if the supply of the service would have high price elasticity.

One way of explaining the price is based on the simple fact that companies need to make profit in the long run. There are costs associated with providing goods or services and those costs need to be covered by revenues. A price might be said to consist of two parts: the seller's cost and the seller's profit margin (see Figure 7). The cost might be higher than the price at some times, which renders a negative profit margin.

---

[22] (Johnson, Scholes, & Whittington, 2008)

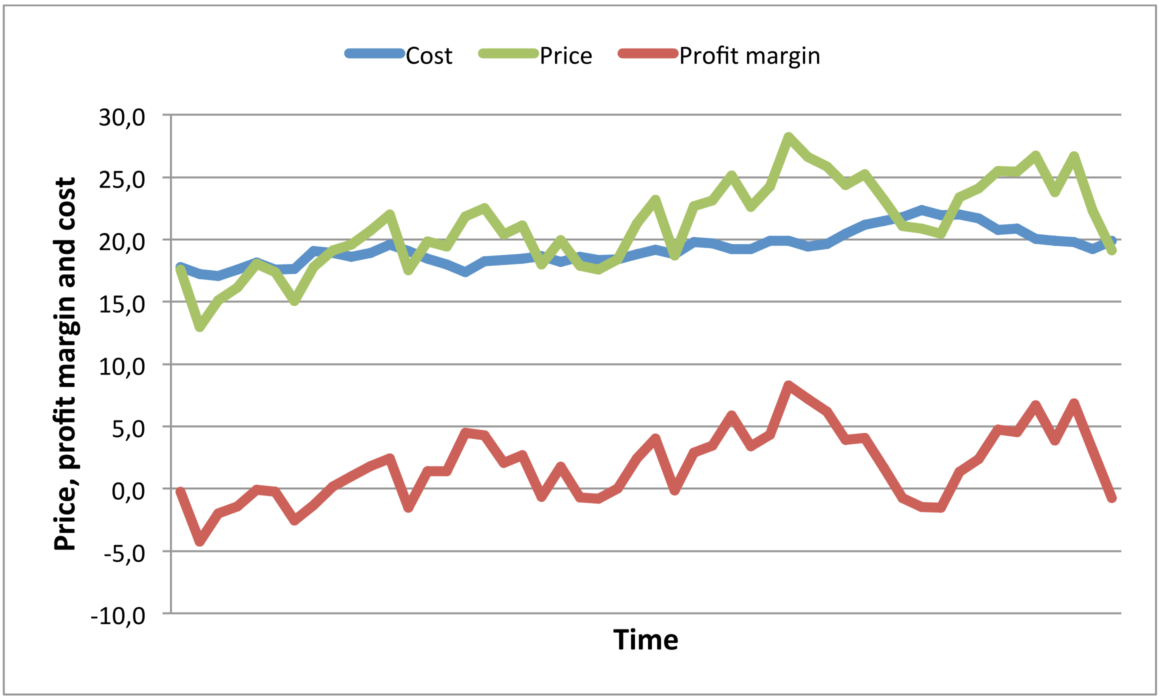


Figure 7: The relation between price, cost and profit margin

For companies only selling one product or one service, such as most shipowners, the profit margin for that product or service needs to be positive on average if those companies are to make any profit. For industries were all companies have the same cost structure for providing the same service and there are few or no possibilities to differentiate the service, the cost plays an important role for explaining the market price. The cost is hence an underlying explanatory variable to the price in such a case. The rest of the price then has to be explained by the profit margin. The profit margin is partly dependent on the market situation, or the demand vs. supply situation previously explained. The profit margin could also be dependent on other factors, such as negotiation skills or choice of contract.[23]

3.2.2 Porter's five forces

To be able to analyze the sea freight market from an industry or microeconomic perspective, the use of Porter's five forces is a good tool. The tool could, as an example, be used to find out how the price in the industry is constructed, which would be of interest according to 3.2.1 above. The framework is only applicable to one specific industry at a time and hence it is important to clearly define the industry of focus before using the framework. The main idea is to identify the sources of competition in the industry. The five forces are: *supplier's power*, which describes the bargaining position for companies supplying the industry with products or services; *customer's power*, the structure of the customers and their ability to influence the industry incumbents; the *new entrants*, discusses the risk of new companies entering the industry; *substitute products*, which describes if there are substitute products or services threatening the industry; and finally

[23] (van Weele, 2005)

competitive rivalry within an industry describing the structure of the incumbent companies and their competition (see Figure 8).[24, 25]

Figure 8: Porter's five forces (Johnson, Scholes, & Whittington, 2008)

A five forces analysis is carried out by identifying and categorizing sources of competition into the framework. Each force is then evaluated based on the impact it has on the overall level of attractively of the industry. E.g. if all five forces is ranked as high, the competition within the industry is fierce and profit margins probably low, rendering the conclusion that the industry is non-attractive. The result of an five forces analysis can be used to explain how the industry is functioning on a microeconomic level. [26, 27]

3.3 Supply chain management: purchasing of transportation services

Rather than talking about supply chain management in general, the focus of this section is on purchasing of transportation services.

The purchasing of a service or goods should be viewed as a process of activities that are tightly interconnected. Van Weele has developed a purchasing process, which consists of six activities: define specification, select supplier, contract agreement, ordering, expediting and evaluation (see Figure 9). The quality of the output of one activity in the process directly affects the quality of the next activity. The result of each step should be concluded and documented before the next step starts.[28]

---

[24] (Johnson, Scholes, & Whittington, 2008)
[25] (Hunger & Wheelen, 2009)
[26] (Johnson, Scholes, & Whittington, 2008)
[27] (Hunger & Wheelen, 2009)
[28] (van Weele, 2005)

Figure 9: The purchasing process (van Weele, 2005)

The first three steps of the process are called the tactical purchasing function and the remaining three the ordering function. Because of the varying nature of the six steps they require different knowledge, skills and expertise in order for a company to reach an optimal solution. This requires different persons, specialized in the different areas of purchasing, to work in cross-functional cooperation. When procuring transportation, it is most often the four later activities in the purchasing process that are carried through.[29]

One important part of the purchasing function is the negotiation. Negotiation takes place between two, or more, parties and the goal of the negotiation is to reach an agreement that is beneficial to all involved. Whom that can benefit the most depends mainly on the power position of involved parties. A purchaser should always strive for a stronger power position in order to be more beneficial in a negotiation. Some important factors improving the power position of a purchaser are: to have more suppliers to choose from, to have the trust of the supplier, to have knowledge about the market and to have knowledge about the supplier in question. Another factor affecting the power position is the amount of money the purchaser can negotiate with. One way to improve the power position is therefore to consolidate all purchasing in a company.[30]

A purchaser of transportation services is just a small part of the supply chain. For a producing company there is a need for transportation for inbound goods to the factory and outbound goods to customers. In a generalized supply chain for a producing company, a seller ensures there is a demand for the product. The factory then need input material for goods, which has to be secured by a commodity purchaser. In order to get the goods to the factory, a transportation purchaser needs to procure the transportation of the goods from the commodity seller to the factory. When the product has been produced, there is again a need for transportation from the factory to the purchaser of the product, which the transportation purchaser has to procure.

If it is the producing company who purchases the transportation, the transportation purchaser has an internal customer, which is the production facility, which must be served with input material. The frames for the inbound transportation is already made up by the commodity purchaser who decides where, when and how much to pick up. The same is true for the outbound transportation where the seller sets the frames. In order to optimize for the entire company, there is a need for coordination between seller, factory, commodity purchaser and transportation purchaser.

[29] (van Weele, 2005)
[30] (van Weele, 2005)

3.3.1 Contracts for sea freight

A purchaser of sea freight has to choose whether to purchase under short term contracts or to set up a long term contract. The advantage with purchasing under a long term contract is that the capacity needed is secured at a previously agreed price. Another advantage is that the purchaser can be certain that the capacity is available when agreed. The main disadvantage is that the purchaser loses contact with the market for sea freight, when only purchasing on long term contract. This problem arises since the suppliers that do not get a contract, are unlikely to inform the purchaser about the market development. Gorton et al. argue that some of the most important ways to acquire market information is through freight negotiations, market reports and information networks with shipowners, charterers, brokers and agents.[31] Some of the different contracts available for sea freight are:[32]

- Voyage charter contracts – spot contract, specified amount between two ports one time
- Contracts of affreightment (CoA) – specified quantity between two areas over a period of time. Often larger quantities that does not fit in one ship.
- Trip-charter contracts – hire ship with crew for the duration of one trip, pay is on a per day basis and charterer pays all expenses during the trip.
- Time-charter contracts – hire ship over a period of time and under certain conditions specified in the contract. Pay is often every 15 days or every month.
- Bareboat or demise charter contracts. – Hire the boat with full operational control over a period of time, charterer has all costs but the capital cost.

What contract to choose depends entirely on the specific situation and the needs of the company procuring the sea freight. It is possible to purchase under any of the contracts mentioned in advance or with short notice, but the voyage charter- and trip-charter contracts normally lasts for a shorter period of time compared to the other contracts. When purchasing with very short notice voyage charter contracts is often the only choice. When purchasing far in advance the voyage charter contract might not be available. Purchasing with the voyage charter contract is often called to purchase on the spot market.

Beside the above contracts there are standard agreement contracts, called Incoterms, that needs to be fulfilled. Which Incoterm to use is decided when selling or buying the goods that needs to be transported. Hence, the freight purchaser focus is on fulfilling the Incoterm of the current contract. For dry bulk cargo two types of Incoterms are normally used: CIF (cost, insurance and freight) and FOB (free on board). Under a CIF contract the seller delivers the sold goods at the purchaser's named port. Hence, with a CIF contract the seller is paying for the sea freight. While, under a FOB contract, the purchaser has to nominate a ship and pay for the sea freight. Hence, while using a FOB contract, the seller´s responsibility ends already when the goods pass the ship's rail at the origin port.[33]

---

[31] (Gorton, Hillenius, Ihre, & Sandevärn, 2009)
[32] (Alizadeh & Nomikos, 2009)
[33] (Gorton, Hillenius, Ihre, & Sandevärn, 2009)

3.3.2 Situations when forecasts can help decision-making

There is a broad range of situations where forward-looking in general, and forecasts in particular, can help decision makers within or with close contact with the shipping industry. Specifically, for transportation purchasers the situations where forecasts is helpful are when making decisions about the mix of long term contracts and spot market contracts. When prices are expected to increase, it is preferred to secure larger capacities with contracts in advance. In case of expected decrease, it is better to purchase the majority of the capacity on a spot market. Accurate forecasts will give the transportation purchaser information that could lead to savings and reduced risks in both a short term and a long term perspective. [34,35]

3.4 Regression analysis forecasting

3.4.1 Forecasting methods

There are various forecasting techniques to choose from, some more suitable for particular situations than others. Therefore, it is important to understand available techniques and their requirements to be able to choose an appropriate technique for a specific situation.[36]

There are four major groups of forecasting techniques: time series, qualitative, casual, and simulation. In *time series analysis*, historical data of the forecasted variable is used to make the forecast. A general assumption, when using this technique, is that the past is a good indicator of the future and a basic requirement is that historical data for the specific variable must exist and be of reliable quality. Time series forecasting of the specific variable is formed as a function of historical values of that variable.[37]

$$forecast\ of\ V = f(time\ series\ of\ V)$$

Qualitative forecasting is based on human judgment and expertise. They are very subjective and are primarily used when historical data is nonexistent and by experts with access to critical market intelligence. Qualitative forecasting can also be used when the time lag is large, e.g. to forecast demand several years into the future.[38]

Casual forecasting techniques model the variable being forecast with other independent variables that influence it. These independent variables hold a significant correlation with the dependent variable. The forecast is hence made as a function of other variables.[39]

$$forecast\ of\ V = f(time\ series\ of\ X, Y, Z, \dots)$$

Finally, *simulation techniques* combine time series and casual methods and results to simulate the forecasted variable. The simulation is designed to imitate the variable.

---

[34] (van Weele, 2005)
[35] (Stopford, 2009)
[36] (Firth, 1977)
[37] (Chopra & Meindl, 2004)
[38] (Chopra & Meindl, 2004)
[39] (Firth, 1977)

It is also essential to define what requirements one have on the forecast regarding e.g. accuracy, cost, time horizon, speed, regularity, detail and relevance. Since some of the desired characteristics are in conflict, e.g. speed and accuracy, one has to balance this trade-off.[40]

In this master thesis, the choice was made to create a casual model, or more specifically a multiple regression model. This since the overall focus of this master thesis was to create a forecasting model for the freight rate movements, which requires a quantitative model. A casual model was chosen over simulation and time series techniques because the available data's frequency and quality was not sufficient to create a time series model. Also, which is addressed later in this report (chapter 5.4 - 5.6), there were strong evidences that the freight rates being modeled were dependent on a number of explanatory factors, a characteristic that is captured by a regression model.

Further, casual models are better adaptable to changes in the environment, since the variable being forecasted is described in relation to other variables. The forecast created from a casual model can also be expressed as a range of outcomes and the reliability of the forecast can be quantified into probabilistic terms. However, a major setback is that a causal model is more costly to create because of the cost of labor to build it and collecting the needed data to test it.[41]

3.4.2 Regression model

Regression analysis quantifies a casual model by modeling one variable on a certain number of explanatory variables. The simplest case is simple linear regression where there is one variable to be forecasted and one explanatory variable. Multiple regression on the other hand contains two or more explanatory variables and can be described as[42]

$$Y = b_o + b_1 X_1 + b_2 X_2 + \cdots + b_k X_k + e$$

where Y is the variable to be forecasted, b_i are weights, X_i are explanatory variables and e is the residual. The residuals are the difference between the actual values of Y and the forecasted values of Y given by the regression.

The coefficients are normally determined by the minimization of the square of the residuals (Least Squares (LS) method).

$$[b_0, \dots, b_k] = arg \min_{b_0, \dots, b_k} \sum e^2$$

There are certain assumptions that are made when using a multiple regression model. These assumptions need to be analyzed in the context of the specific problem to understand the suitability of the model. The assumptions are:[43]

---

40 (Firth, 1977)
41 (Firth, 1977)
42 (Firth, 1977)
43 (Makridakis, Wheelwright, & Hyndman, 1998)

1. *Model form* – the relationship between the forecast variable and the explanatory variables needs to be correct. E.g. if the relationship is linear it should not be non-linear in the model. If the model is incorrect the forecasts may be inaccurate and significance tests will not be strictly valid.
2. *Independence of residuals* – If the residuals are not independent, significance tests are not strictly valid and the estimated coefficients may be unstable.
3. *Homoscedasticity* – this is the assumption that the residuals should have a constant variance. If this is not the case, the statistical tests might not be valid.
4. *Normal errors* – the residual term is assumed to be approximately normal distributed. If this is not fulfilled the significance tests are affected. However the model's ability to forecast and the accuracy of the coefficients will not be affected. This is a less serious assumption due to the fact that many unimportant factors are acting together to influence the forecast variable and the net effect of that influence can reasonably well be modeled by a normal distribution.

3.4.3 Creating the regression model

To create a regression model one first has to use experts and previous research to come up with a long list of potential explanatory variables for the forecast variable *Y*. When this long list is created it should be reduced to a shorter list by a number of different methods. The goal of this process is of course to find the explanatory variables that best model the forecast variable *Y*, without having to construct and test all possible combinations of variables. For example when there are 44 possible explanatory variables, there are 2^{44} = 18 000 000 000 combinations.

Some of the methods that can be used are very straightforward, but not reliable in finding a good model, for example:

- Plot *Y* against the potential explanatory variable X_j and if there is no noticeable relationship drop it.
- Look at all possible correlations between potential explanatory variables (intercorrelations), and remove one of the two variables from further consideration if a large correlation is found.
- Do linear regressions for all variables and remove the variables with a low *t* value (when the coefficient is not significantly different from zero).

There are other methods that give better answers but also carry a higher complexity, for example the best subsets regression and a stepwise regression.

In the best subsets regression, a computer program identifies the best models with only one explanatory variable, the best models with two variables, and so on. Then, the program expands only on these models to find the best model based on R^2*, a measure describing the accuracy of the model (see chapter 3.4.4). This method saves a lot of calculation time compared to checking all combinations.

The stepwise regression could be done backward, forward and forward-with-a-backward-look. Where the forward method starts by finding the variable with the highest correlation to *Y*. A regression is made with this variable and the residuals are calculated. These residuals form the new *Y* and again a correlation test determines which variable that has the highest correlation. This process is continued in the same fashion until there are no remaining explanatory variables with a significant relationship to the current residual.

Backwards regression is based on a similar idea, but instead a regression of all variables are performed in the start. Then the variable with the least significance (based on *t* value) is removed and another regression is performed on the remaining variables. This process is repeated until the model is sufficiently good.

Finally the forward-with-a-backward-look stepwise regression follows a slightly more complicated scheme that is explained below using the same notation as earlier.[44]

1. Find the best single variable X_1 maximizing R^2*(see chapter 3.4.4)
2. Find the best pair of variables (X_1 together with one of the remaining variables X_2)
3. Find the best triple of explanatory variables (X_1, X_2 plus one of the remaining variables X_3)
4. From this step on check if any of the previously introduced variables might conceivably have to be removed. E.g. there might be that X_2 and X_3 gives a higher R^2* than X_1, X_2 and X_3.
5. The process of checking both for the next best explanatory variable to include and if a previously included variable could be removed is repeated, until a certain criterion is fulfilled. For example until the probability of entering and/or removing another variable is at a certain threshold.

In this master thesis an intercorrelation test will be used initially to remove the most related variables and create a more balanced set of potential explanatory variables. Then a forward-with-a-backward-look stepwise regression will be used to find potential model candidates.

3.4.4 Evaluating the regression model

Three steps are necessary to evaluate the regression model: checking the model accuracy, checking that the regression assumptions holds and examine the forecasting accuracy.

Model accuracy

To test the accuracy of a model, one can use the following methods: correlation, R^2 and R^{*2}.

Correlation is a special case of covariance, which measures how two variables co-vary, i.e. the closeness of their relationship. If the covariance is positive, the variables have a tendency to move in the same direction, while if the covariance is negative the variables are more likely to move in opposite directions. Correlation is a scaled form of covariance, which can only take values between -1 and 1. The correlation is normally defined as

$$r_{XY} = \frac{Cov_{XY}}{S_X S_Y} = \frac{\sum(X_i - \bar{X})(Y_i - \bar{Y})}{\sqrt{\sum(X_i - \bar{X})^2}\sqrt{\sum(Y_i - \bar{Y})^2}}$$

[44] (Makridakis, Wheelwright, & Hyndman, 1998)

where X and Y are the variables being examined. $\bar{X}$ and $\bar{Y}$ are the average values of the respective variables.[45]

R is called the multiple correlation coefficient equation and measures the correlation between the forecast variable *Y* and the estimated $\hat{Y}$ based on the multiple regression model. The *R* statistics measures the overall significance of the model. The *R*-statistic is normally formed squared

$$R^2 = \frac{\sum(\hat{Y}_i - \bar{Y})^2}{\sum(Y_i - \bar{Y})^2}$$

where R^2 measures the ratio between the variance in the estimated values and the variance of the actual forecast variable. Hence, this is a measure of the proportion of the variance in Y that can be explained by the X_i variables. Of course, it is positive to have a value of R^2 that is as close to 100 % as possible.[46]

However, there is a problem with R^2, because it does not take into account the degrees of freedom. Actually, a model with the maximal amount of variables will always have a higher R^2 value than any combination of the same variables (with fewer total amount of variables). To solve this problem, there is an adjusted R^2-statistics, in this report described as R^{*2} formed as

$$R^{*2} = 1 - (1 - R^2)\frac{n-1}{n-k-1}$$

where *n* is the number of observations and *k* is the number of explanatory variables being used in the model. Since the *k* is in the denominator models using many variables will be penalized.[47]

Assumption tests

There are a number of tests that can be done to verify that the four assumptions of a regression model holds. The first assumption, model form, can be tested by looking at plots of the residuals of the model and the respective explanatory variables. For example if the assumption of the model structure was that variable had a linear relation with the forecast variable and the plot shows pattern of curvature the linear assumption was incorrect. The third assumption, homoscedasticity, can be tested in a similar way by looking at the plot between the residuals and the forecasted variable.[48]

The second assumption, independence of the residuals, can be checked with a number of methods. First, a simple plot of the residuals over time can show certain correlations and trends. A more robust method, however, is to calculate the autocorrelation function for the residuals as

[45] (Makridakis, Wheelwright, & Hyndman, 1998)
[46] (Makridakis, Wheelwright, & Hyndman, 1998)
[47] (Makridakis, Wheelwright, & Hyndman, 1998)
[48] (Makridakis, Wheelwright, & Hyndman, 1998)

$$r_k = \frac{\sum_{t=k+1}^{n}(e_t - \bar{e})(e_{t-k} - \bar{e})}{\sum_{t=1}^{n}(e_t - \bar{e})^2}$$

where k is the lag, e_t is the residual at time t and n the number of observations. The autocorrelation can then be plotted for different lags k. The autocorrelation should be zero for each lag k larger than zero. To verify that the autocorrelation is significantly non-zero one can create confidence intervals.[49]

The Durbin-Watson (DW) statistics is a supplement to the autocorrelation function and tests for autocorrelation at lag 1. The most common autocorrelation exists at lag 1, hence that knowledge gives a good indication of higher lag autocorrelation as well. The DW-statistic is defined by

$$DW = \frac{\sum_{t=2}^{n}(e_t - e_{t-1})}{\sum_{t=1}^{n} {e_t}^2}$$

where n is the number of observations and e_t the resiudal at time t. The DW-statistic ranges in value between 0 and 4, with the intermediate value of 2. Values below 2 indicate a positive autocorrelation, while values above 2 suggest a tendency for negative autocorrelation. Especially formed Durbin-Watson statistical tables can be used to verify that the residuals are significantly non-autocorrelated at lag 1.[50]

The forth assumption, normality, can be tested by plotting a histogram of the residuals and comparing with the expected normality curve and by using the Jarque-Bera test. The Jarque-Bera test checks if the residuals fit the normal distribution with respect to kurtosis and skewness, which should equal zero, the test statistic is formed as

$$JB = \frac{n}{6}\left(S^2 + \frac{1}{4}K^2\right)$$

$$S = \frac{\frac{1}{n}\sum_{i=1}^{n}(e_i - \bar{e})^3}{\left(\frac{1}{n}\sum_{i=1}^{n}(e_i - \bar{e})^2\right)^{3/2}}$$

$$K = \frac{\frac{1}{n}\sum_{i=1}^{n}(e_i - \bar{e})^4}{\left(\frac{1}{n}\sum_{i=1}^{n}(e_i - \bar{e})^2\right)^{2}} - 3$$

where n is the number of observations, S is the skewness and K the kurtosis of the residuals e_i. The JB statistic, which is asymptotically chi-squared distributed (with two degrees of freedom), is evaluated to verify if the residuals are normally distributed or not. For small sample sizes, the chi-squared approximation does not hold, Monte Carlo simulated values can be used to determine the normality of the residuals.[51]

---

49 (Makridakis, Wheelwright, & Hyndman, 1998)
50 (Makridakis, Wheelwright, & Hyndman, 1998)
51 (Mooney, 1997)

Forecasting accuracy

In order to test the forecasting accuracy of the model, the forecasted values are compared to the real observations which the model is supposed to forecast. To get conclusive results of the forecasting accuracy, those observations should not have been part of the data used to construct the model. Both *mean squared error (MSE)* and *mean absolute percentage error (MAPE)* can be used to compare different models forecasting accuracy. These measurements are defined as

$$MSE = \frac{1}{n}\sum_{t=1}^{n} {e_t}^2$$

$$MAPE = \frac{1}{n}\sum_{t=1}^{n} |PE_t| = \frac{1}{n}\sum_{t=1}^{n} \left| \left(\frac{Y_t - \hat{Y}_t}{Y_t} \right) \times 100 \right|$$

where n is the number of observations and PE_t the percentage error in time.

It is also possible to create confidence intervals for the forecasted variable. The width of the interval, z, is dependent on what probability that is discussed, and the intervals is formed as

$$\hat{Y}_t \pm z\sqrt{MSE}$$

By using confidence intervals one can show the difference in accuracy between different models.[52]

3.4.5 Using regression to forecast

There are several methods that could be used to construct a forecast for a regression model. The choice of method is dependent on the time lag of the explanatory variables. A future prediction of k periods for the forecast variable Y can be performed without any forecasts of the explanatory variables, if the explanatory variables have a time lag of minimum k lags. E.g. if the forecast variable is sold goods with the explanatory variables demand four months earlier and corporate bonds yield five months earlier, a four month prediction of the forecasted variable can be made right away because of the chosen model structure.[53]

3.4.6 Moving average

The trend cycle of time series can be estimated by the use of moving average (MA). A moving average smooth the series and reduces the impact of random variation. The simplest way to form an MA is to use a Simple Moving Average. The basic idea behind this method is that observations that are adjacent in time also should be close in value. Hence, taking an average of the points near an observation should give a good estimate of the trend cycle at that observation. The Simple Moving Average is constructed as

[52] (Makridakis, Wheelwright, & Hyndman, 1998)
[53] (Makridakis, Wheelwright, & Hyndman, 1998)

$$T_t = \frac{1}{k} \sum_{j=-m}^{m} Y_{t+j}$$

where T_t is the trend at time *t, k* is the order of the moving average, $m = (k\text{-}1)/2$ defines the adjacent points that should be included and *Y* is the observation. For example a MA3 is a moving average of order 3 (k = 3),

$$MA3: \qquad T_t = \frac{1}{3} \sum_{j=-1}^{1} Y_{t+j}$$

which is calculated using the value one time point before the observation, the value of the actual observation and the value of the following time point.[54]

---

54 (Makridakis, Wheelwright, & Hyndman, 1998)

4 Methodology

In this chapter the methodology of the master thesis is discussed. The overall process used and the included activities are defined. The chapter forms the basis of the thesis and describes how and why the research was performed in a certain way.

4.1 Overview

The main purpose of this thesis is to give Lantmännen information that will give them an opportunity to make better decisions in purchasing of freight services. This is done by developing a price forecasting model for sea freights.

To be able to deliver an end product of high quality, extensive thought and planning was put into what activities that should be performed and in what order. The most important activities are discussed throughout this chapter with the overall working structure shown below (see Figure 10).

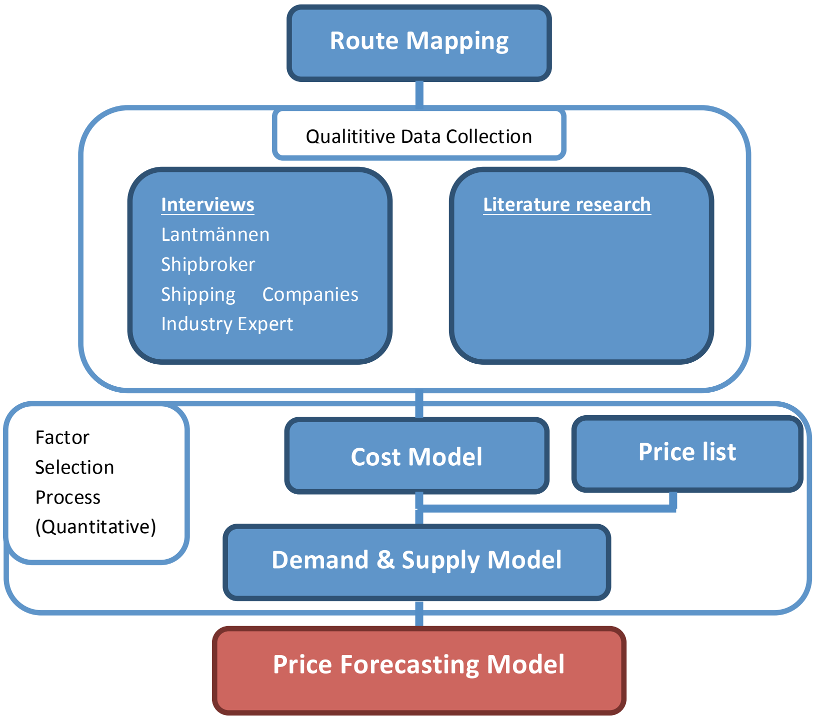


Figure 10: Overall structure of the master thesis

The work started with the creation of a Route Mapping of Lantmännen's shipping network, this to be able to focus the study only on the routes used by Lantmännen. This was followed by a block of Qualitative Data Collection where knowledge was gathered from key participants within the industry and academia through interviews and literature research. This new knowledge together with collected price data formed the framework of the Factor Selection Process that applied quantitative methods to create a Cost Model and a Demand & Supply Model. Lastly these two models were combined to create a tool for price forecasting.

For a more detailed description of the working structure of this master thesis see chapter 4.4.

4.2 Ambition and purpose

Research projects have defined purposes, depending on the depth and extent of these and the previous knowledge within the research area a certain ambition level for the research is preferable. A suitable ambition level is important for the research to be able to deliver according to the expected result. Examples of ambition levels, with growing depth and complexity, are problematization, exploratory, descriptive, explanatory, predictive and normative.[55]

The overall purpose of this master project is: *To provide Lantmännen with information, that help them make better decisions when procuring sea freight services, by developing a price forecasting model.*

Based on the above purpose for this particular master thesis, the overall ambition level is to be *predictive*. The choice of this level is motivated by the end-product being a forecasting model. I.e. the research needs to understand the problem to such an extent that forecasts are accurate.

4.3 Choice of methodology

Jacobsen describes the first methodology problem as the choice between the *inductive* and the *deductive* approach of data collection. In the deductive approach the researcher has a number of expectations and theories about their area of research and then uses an empirical study to verify if these expectations fit the reality. The deductive approach can be said to have the process "from theory to empirics". In the inductive approach the researcher should look at the reality open-mindedly without any expectations and theories, and collect and structure relevant data to create new theories. Therefore the inductive approach can be simplified as a process "from empirics to theory". The inductive approach has the advantage of a broader initial scope where nothing should limit the information collected by the researcher. However this approach might be very time-consuming because of very lose initial constraints and delimitations.[56]

It is also possible to use a combination of the inductive and deductive approach that is called abduction. In this approach the researcher can use positive aspects from both the inductive and deductive approach. For example it is possible to use an inductive approach initially to gather information without expectations, but to later switch to a deductive approach to focus the data collection on a few areas.[57]

In this master thesis the abduction approach is used, because it was desirable to use a method that initially has a broad perspective but also to later focus on a few important findings and perform deeper analysis on those. Therefore the research initially had an inductive approach which in a later stage changed to a deductive approach (see Figure 11).

[55] (Wallén, 1996)
[56] (Jacobsen, 2002)
[57] (Holme & Solvang, 1997)

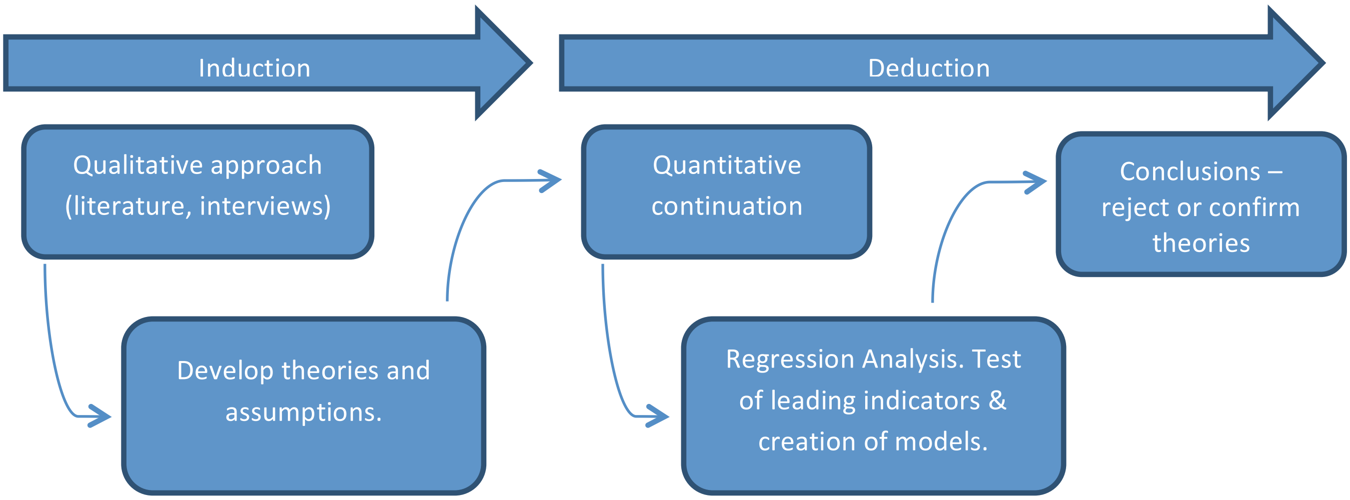


Figure 11: Inductive and deductive combination approach

The inductive part of the research consists of a qualitative data collection with literature study and interviews. The literature being studied is written by experts within both academia and industry, which serves to give the researchers a broad introduction to the industry. The interviews conducted have the purpose of collecting qualitative information about the problem from different actors within the industry.

The knowledge collected from literature and interviews was compiled and summarized into a number of theories that formed the basis for the deductive part of the research. These theories were later tested in a quantitative environment, by model building and regression analysis. Among other quantitative tools, correlation analysis was used to be able to reject or confirm theories collected from the inductive part.

First, the qualitative and inductive start narrows down the focus on a limited number of theories to be tested with quantitative methods. It would not have been feasible to perform quantitative tests without this focus, because of time constraints. Second, the deductive approach is in some sense testing the quality of the inductive study and its theories. Hence, all theories and assumptions that are confirmed in the final conclusion are very reliable because of this approach of both quantitative and qualitative methods and tests.

This combination of an inductive and a deductive approach is closely connected to the usage of both qualitative and quantitative methods for data collection (see chapter 4.5.1).

4.4 Research design

The detailed research design for this master thesis is discussed in the following paragraphs and illustrated by the below Figure 12. The arrows to the far left describe the overall distinction of the research into three steps 1, 2 and 3. Step 1 consisted of the inductive approach discussed above, with interviews and literature research. Step 2 was the deductive part of the process, where quantitative methods were used to test and further develop the findings from step 1. Finally, step 3 combined the cost model and the demand & supply model into a forecasting model, the actual tool that is to be used by Lantmännen.

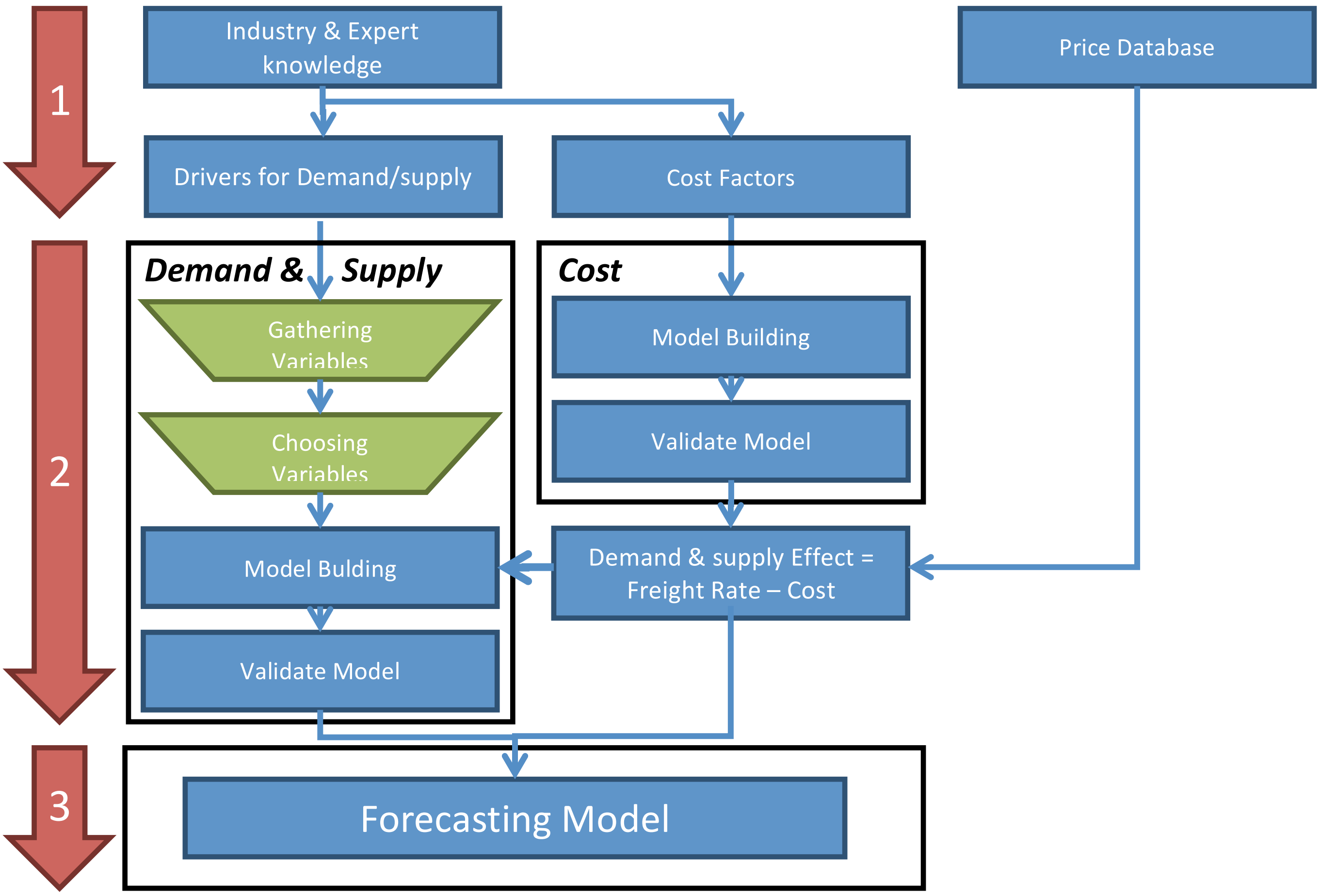


Figure 12: Detailed research design of master thesis

4.4.1 Step 1 – Data collection

In Step 1, industry and expert knowledge about the shipping industry was collected through interviews and literature review. This resulted in a collection of cost factors and drivers for demand/supply in the market. The cost factors were primarily collected through interviews with shipowners and shipbrokers, while the demand and supply factors were gathered mainly from transportation purchasers and shipbrokers. Step 1 also included the activity of building a price database by collecting and combining shipping data from Lantmännen's different business units (Spannmål, Foder and Cerealia DK) into one single database.

4.4.2 Step 2 – Model development

Step 2 consisted of the two major processes of creating a model for costs and a model for demand and supply. The cost model was created to be able to calculate accurate cost estimates for a certain ship on a specific freight route. The model for costs is based on the cost factors that were found in Step 1. When possible the cost factors were paired to an actual quantitative index (e.g oil price index, inflation index), available on the market. The cost factors that could not be based on an external index were quantified in numbers based on the findings from Step 2 (e.g. the maintenance cost is based on interview results from shipowners and from literature). When all costs were quantified the cost model was able to calculate the cost for every ship on each route used by Lantmännen. The accuracy of the cost model was verified mainly by comparing the estimated fixed costs of a certain ship with its demurrage. The final cost model was able to calculate all costs, and hence the cost for every single transport could be subtracted from the freight rate, leaving the demand and supply effect as the difference. This effect is the underlying data that the demand & supply model was based upon.

The demand & supply model was created with the aim to model the part of the freight rate that is dependent on demand and supply, and not on the actual costs for the shipowner. First, a number of indices were gathered based on the information of demand and supply drivers gathered from Step 1. Secondly, when a large number of quantitative indices were found, statistical and logical techniques was used to decide whether the indices were relevant, i.e. if an index could actually be used to model the demand and supply effect. Thirdly, when the set of possible indices was created a regression model was built, according to the theory described in chapter 3.4. The regression model used the algorithm of forward-with-a-backward-look to find the indices that were most suitable to model the underlying demand and supply effect. The demand & supply models were created with a maximum limit of five separate indices. The choice of using five indices is based on the notion of keeping the model updating fairly easy. The limit also allows a more straightforward interpretations and analysis of the combination of indices used by the model. The finished demand & supply model was validated by performing a residual analysis; checking the model's fit and its prediction accuracy.

4.4.3 Step 3 – Usability, design and evaluation of the forecasting model

In Step 3 the cost model and the demand & supply model were merged into a forecasting model. The step also includes a discussion about how Lantmännen should use the final forecasting model. The design of the final model is constructed to best enable and ease the usage that is recommended. This final forecasting model is also tested to verify that it accurately can forecast the future freight rates on the market. Finally the forecasting model is evaluated from a qualitative and long-term perspective, with a short discussion regarding the models overall validity.

4.5 Data collection methodology

This section describes the different information sources used in the data collection part of this master thesis.

4.5.1 Qualitative/quantitative and primary/secondary data

All data can be characterized as being either quantitative or qualitative and also either primary or secondary. Primary data is information that has been collected by the researcher directly from the primary information source, e.g. by interviewing an expert. The data collection for primary data is tailor-made to the specific research area.[58] Secondary data is contrary to primary data not collected directly from the source. Secondary data is data that initially has been gathered by someone else, and in most cases not with the intent to study an identical area.[59]

---

[58] (Jacobsen, 2002)
[59] (Jacobsen, 2002)

Quantitative data is normally made up of numbers, instead of words, and is used when there is good knowledge about the studied area and when the purpose of the study is clear. Quantitative data is typically used when many objects needs to be studied before conclusions can be made. Qualitative data is, in contrast to quantitative data, mainly consisting of words. Qualitative data focuses on describing and understanding a situation. It is normally more resource demanding to gather qualitative data.[60]

The usage of different kinds of data is ideal to get reliable research results. This is because the different types of data ultimately confirms/rejects each other and give an indication of the result's quality.[61]

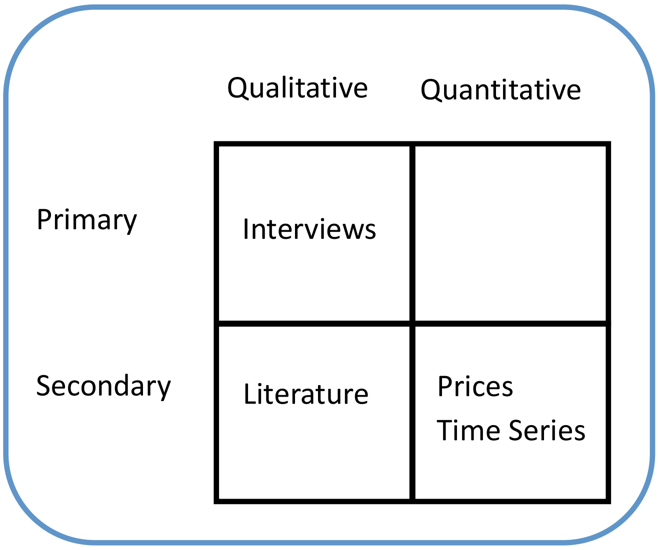


Figure 13: Qualitative/quantitative and primary/secondary data in the master thesis

The above Figure 13 describes the types of data used in this master thesis. In the upper left corner there is qualitative primary data, which in this thesis is data collected from interviews with people from Lantmännen, shipbrokers, shipowners and other organizations.

Literature research is a sort of qualitative secondary data shown in the lower left corner of Figure 13. Literature research was used to get in-depth analysis of previous research about what effects the price of sea freight services.

Shown in the lower right part of the figure is quantitative secondary data, which was collected in the thesis in the forms of price data and a number of different time series (indices).

4.5.2 Interviews

As mentioned above, this master thesis includes interviews with Lantmännen employees, shipbrokers and shipowner representatives (all presented in Table 1 below). Since these interviewees possess different knowledge, the focus of the interviews differed. The interviewing agenda and questions used can be reviewed in Appendix B.

---

[60] (Jacobsen, 2002)
[61] (Holme & Solvang, 1997)

Table 1: Compilation of Interviewees

Name	Title/Role	Company
Ann-Marie Tidén	Logistic Coordinator	Lantmännen – Feed & Cerealia Sweden
Björn Andersson	Harbour Manager	Lantmännen – Malmö hamn
Erika Bjurling	Team Leader Shipping	Lantmännen - Feed & Cerealia Sweden
Ingemar Steneholm	Chartering	Lantmännen - Feed & Cerealia Sweden
Flemming Olsen	Trader	Lantmännen – Cerealia Denmark
Michel van Keulen	Shipbroker	LBH Shipbrokers
Mattias Lind	Shipbroker	Ivar Lundh & CO
Holger Trost	Shipbroker	Ahlmann-Zerssen
Peter Anderson	Shipowner	Jönsson Novabolagen AB
Gregor Loebbert	Shipowner	OP Svensson Shipping & Forwarding AB

The interviews with employees from Lantmännen primarily focused on the purchasing processes and methods they use. This information enabled the authors to better understand in what way the forecasting model should be created to maximize the usage and value for the purchasing organization.

The primary aim when interviewing shipbrokers were to understand the nature of the market, and specifically how the price is decided in the market. Shipbrokers have a great overview of transactions taking place in the market and therefore they possess knowledge on what factors that seems to affect the demand and supply.

When meeting shipowners the most important information to gather was their declaration of shipping cost. Since the shipowners are the companies that are actually carrying out the freight service, they possess valuable knowledge about which costs they have and how these costs depends on other factors/indices.

All interviews were of the semi-structured type, where an agenda was used to guide the interviewing process. The agenda was shared with the interviewee in beforehand to prepare him/her for the subjects to be discussed. The agenda was primarily a guide and not a strict scheme, which enabled a semi-structured discussion where the authors were able to focus on subjects were the the interviewee had interesting thoughts and/or valuable knowledge and input. When referencing the interviews the interviewees' roles will be used instead of their names. This is so that it should not be possible to trace specific statements to specific persons, which were agreed upon during the interviews.

According to Kvale, there are several different qualification criteria for the interviewers, e.g. to be knowledgeable, structuralizing, controlling, open, critical and interpretive.[62] To fulfill these criteria, the authors of this master thesis have allocated time to gain basic knowledge of the industry and the specific problem, but also to study and learn suitable interviewing methods and to plan and create interviewing material.

[62] (Kvale, 1997)

4.5.3 Literature study

Literature study is the process of researching existing literature, to create a broader base of knowledge and understanding for a problem area. Literature is collections and finished analysis of previously gathered data, i.e. a qualitative study of secondary data. In this master thesis the primary purpose of the literature study was to get a quick read-up within the subject to be able to comprehend the basics and the terminology of the industry. The knowledge gained was also essential to be able to perform effective interviews, e.g. because of the ability to ask relevant follow-up questions. The most important literature that was studied is listed below (see Table 2), for all references see the bibliography.

Table 2: List of most important litterateur on sea freight industry

Author	Title
Alizadeh & Nomikos	Shipping Derivatives and Risk Management
Gorton et al	Shipbrokering and chartering practice
Stopford	Maritime economics

4.5.4 Time series

All the time series and indices were obtained from Thomson Reuter´s time series database DataStream. This database contains 140 million time series that are sorted into different categories and are searchable using keywords. The database is accessible for subscribers only.[63] A brief summary of the different categories from which the time series were collected is presented in Table 3.

Table 3: Brief summary of categories of time series that were acquired.

Deep sea freights	Grain Price
World Economy Growth	Ore Price
Chinese Import/Export Activity	Coal Price
Mineral Industry	Scrap Metal Price
Wood Industry	Other Commodity Prices
Agriculture Industry	Exchange rates
Construction Industry	Interest rates
Bunker Fuel Price	Inflation rates

4.6 Research quality

Research quality is dependent on the whole research method and especially concerns the quality, and hence the usage of the empirical results. The empirical results that follow from any method must fulfill at least the two requirements of being valid and reliable to be considered holding a sufficient quality.

The validity is determined by internal and external validity. Internal validity means that the research actually measures what was supposed to be measured. While external validity concerns if the results, based on data from a specific situation and setting, are transferable to another

[63] (THOMSON REUTERS, 2010)

context. The reliability of the research concerns the trustworthiness of the method and the overall result. The method must be credible and the results can not contain any obvious errors. If the reliability is high the research results should be repeatable, i.e. if the research was conducted again the same results would be generated.[64]

In this master thesis the internal validity is kept high through a broad approach used in the qualitative part of the study. This approach results in a broad understanding of the causality of the specific problem and the industry in general.

The external validity in the study is high in the context of similar types of smaller shipping since the results can be used for all companies with wholly or partly similar transportation needs. However, the results are probably not possible to generalize on other types of transportation or non-similar sectors within the shipping industry. Although, the results are not, the actual method approach used in this master thesis is however applicable to other industries and other transportation problems.

The reliability of the results is on a high level because of the research method's abductive approach, with an initial qualitative step that is later backed up by a quantitative study. This approach serves to minimize the chance of system and measurement errors, because all quality results are tested in a quantitative environment. E.g. a result from the qualitative study was that several of the interviews claimed that the Chinese economy affects the demand, this claim was tested quantitatively by performing statistical analysis on different indices describing the Chinese economic development and its effects on the identified demand.

The research quality of the interviews was kept high because of follow-up questions and the fact that both researchers interpreted all information. Follow-up questions were frequently used on strong and important statements to validate that we correctly understood the interviewee's opinion. Kvale (1997) also means that if more than one person interprets the same interview the subjectivity is better controlled.[65]

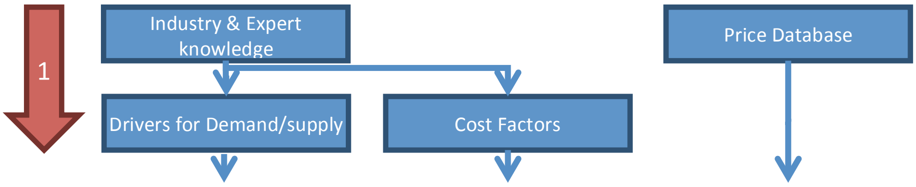
To verify that the actual model created held a high quality, a number of different statistical tools (described in 3.4 Regression analysis forecasting) were used both during the creation of the model and to evaluate the finished model. Regression analysis was used to decide, which explanatory variables that were significantly affecting the forecast variable. To compare different model setups tools as R^{*2} and residual analysis was used to evaluate, which models that had a good fit to the underlying data. The model's overall forecasting ability, i.e. the ability to forecast trends, was tested by using MSE and MAPE measurements. The model's ability to forecast specific freight rates on a certain number of example routes was also tested by looking at the model's forecast on historical periods. Logical test were also performed by the authors.

In the conclusion chapter, there is a section concerning the research quality of the whole master thesis process and its final results (chapter 8.2).

---

[64] (Jacobsen, 2002)
[65] (Kvale, 1997)

5 Step 1 – Data collection



According to the methodology of this master thesis the first of three parts of the research process was the data collection. This step included collection of industry and expert knowledge about the shipping industry, specifically cost factors and drivers for demand/supply in the market. This step also included the activity of building a price database, by collecting and combining shipping data from Lantmännen's different business units (Spannmål, Foder and Cerealia DK), into one single database. In this chapter the result of the activities from Step 1 is presented.

5.1 The shipping industry

The shipping industry is complex and for the tonnage in focus for the thesis (500-10 000 DWT), there is little research done. There exists no transparency of costs between companies, no indices and there is in general little written about this market. The most common owner structures for ships of these sizes are: family owned, owned by banks or other financial institute or limited partnerships. Shipowners often outsource the commercial management to a shipbroker, who make sure to arrange freights for the ship.[66]

There is an imbalance of flow in the Baltic area due to higher volumes of export than import. When going back into the Baltic, ships face a problem of finding cargo and it is not uncommon that ships return empty. Because of this imbalance the return journey is referred to as "taking position", i.e. moving to a position where freights are available.[67]

Dry bulk ships can handle different types of cargo such as: grain, feedstuff, fertilizers, coal, ore, cokes, stone, scrap metal and even wind power stations. There is little or no cost for changing between different types of cargo: only a basic cleaning is needed, which is quickly done by the crew. Even though the possibility exists, it is highly unusual that two freight purchasers ship their goods on the same ship.[68]

In case of ice forming, the ships need to have a sufficient ice classification or they are not allowed to travel in the waters were ice has formed. The thicker the ice, the higher ice classification needed. When there is ice, there are often large delays. Also, the freight rates are

[66] (Shipowner, 2010)
[67] (Shipbroker, 2010)
[68] (Shipowner, 2010)

higher, since a fewer number of ships are available for the freight purchasers to choose from and negotiate with.[69]

5.1.1 Determination of freight rates

A shipowner, who is requested for an offer, starts by calculating his costs for the journey. Second, he decides on a profit margin. How large this could be depends on the market situation. Most shipowners and shipbrokers have a feeling for the current market situation, acquired by their information channels. The most important channels are: negotiating freights, following market reports and talking to their network of shipbrokers, customers, shipowners and industry analysts. They also look at things such as world market, Chinese activity, supply of ships in the region, fuel prices, commodity prices and speculations of future prices. After the freight rate has been offered, there can be a negotiation with the freight purchaser and depending on the power situation the price might change.[70]

5.2 Lantmännen's point of view

Lantmännen have, simplified, two types of flow. One is the import of input goods for feedstuff manufacturing to Sweden from Germany and Netherlands. The other flow is the export of grain from Sweden to Germany, Netherlands and Spain. The commodities are usually sold with future contracts long time in advance of the shipping date, but sometimes with shorter notice. This is done by traders at Lantmännen, whom are not connected to the supply chain of the company. For the Foder section, goods are purchased to match the expected production of feedstuff on contracts with flexibility since Lantmännen work in a just in time supply strategy in their factories. There is one planner at each factory that makes sure that there are no shortages in the factories and at the same time not too much in the warehouse. The planner is also the freight purchaser. When goods are purchased or sold, a contract is written. The two Incoterms used in those contracts are mainly CIF and FOB. It is the planner´s task to conclude the contract by finding a ship that can fulfill the requirements stated in the contract. There are few initiatives for coordination between the internal sectors of Lantmännen and they never ship together with external non-Lantmännen companies.[71]

The freight purchasers at Lantmännen are in daily contact with the shipping market. Shipbrokers or port agencies sometimes signal that they have open ships and are interested in shipping cargo for Lantmännen.

Lantmännen have certain requirements on the ships that they are using:[72]

- Should not be older than 30 years. Otherwise the insurance company needs to make a special approval.
- Should be easy to load and unload (only single decker with clean and easy-to-access cargo holds)

---

[69] (Shipbroker, 2010)
[70] (Shipowner, 2010)
[71] (Person within Lantmännen, 2010)
[72] (Person within Lantmännen, 2010)

- Comply with GAFTA
- The ship must be approved by the Swedish labor union.
- For traffic within Sweden the ship must be registered in the EU.

There is no corporate strategy or defined process for procuring sea freight. The directions are that the freight should be secured as soon as possible, but freight purchasers are free to decide for themselves if they want to wait for the prices to decline. Lantmännen mainly purchases freight services on the spot market and they do not work with a list of selected suppliers. In order to understand if a price offered is good or not, freight purchasers at Lantmännen use their experience and feeling. This feeling is based on daily contact with the market via shipbrokers, agents, shipowners and market reports.[73]

Besides from purchasing on the spot market there is one supplier that is under a contract with Lantmännen. The contract states that rates are updated once every third month according to the consumer price index in Sweden. Those rates are valid only for freights between Swedish ports. There exists no transparency of costs between Lantmännen and any shipbroker or shipowner and Lantmännen have never demanded to see the actual costs for the transports that they purchase.[74]

Lantmännen have a seasonal demand for sea freights for grain, but not as much for feedstuff inputs. Their demand for shipping grain is most intense at the harvests season, which takes place from late July to early October. For the Foder section, there is a slightly higher demand in December.[75]

5.3 Database of historical sea freight rates

As described earlier, Lantmännen has two main flows, but they also have some minor flows that are internal. Data from historical sea freights was collected from the Foder section and the Spannmål section respectively. Data was also collected from Cerealia in Denmark, where the main flow is from Sweden to Vejle in Denmark. Data from Foder and Cerealia was obtained by email from persons within the two sections. Data from the Spannmål section was obtained without freight rates since this was not reported into their systems. The freight rates were found in archives in Norrköping and Malmö and the data was manually complemented. The total amount of observations acquired was 4 341 during the period February 2005 to November 2010. Out of this 2 208 observations was from the Spannmål section, 1 1815 from the Foder section and 318 from Cerealia DK (see Table 4).

Table 4: Summary of all freight data collected from Lantmännen

Section	Spannmål	Foder	Cerealia DK
Number of observations	2208	1815	318
Period of time	Jan 2006 - Nov 2010	Feb 2005 - Nov 2010	Jan 2008 - Nov 2010

73 (Person within Lantmännen, 2010)
74 (Person within Lantmännen, 2010)
75 (Person within Lantmännen, 2010)

The data presented in Table 4 was good for understanding the major flow of goods since most observations contained departure port, destination port, shipped volume and a date; however some of the information needed to build the model were missing from many of the observations. The information that was required for the model building was: date of departure (or arrival), area/port of departure, destination area/port, name of ship, shipped volume and the freight rate. Out of the 4 341 observations originally acquired, 1067 contained this information (see Table 5 for how the observations are divided on the sectors).

Table 5: Summary of freight data usable for creating a model

Section	Spannmål	Foder	Cerealia DK
Number of observations	233	516	318
Period of time	Sep 2006 - Nov 2010	Jan 2008 - Nov 2010	Jan 2008 - Nov 2010

As can be seen when comparing Table 4 with Table 5, there were no observations removed from the data provided by Cerealia DK. This data should hence be a perfect representation of the historical freight rates paid by Cerealia DK.

For Foder, the primary reason for the loss of data was that data regarding the ship was missing from data before January 2008. The second reason was that the freights were under CIF contract and that freight rates did not exists. Taking this into account, there were only 10 observations that were removed for missing any other information. The remaining data is hence a good representation for the years 2008-2010.

For Spannmål, the reason for the loss of observation was that the majority of the original 2208 data missed freight rates. Initially all observations missed data on freight rate, but investigations of Lantmännen's archives in Norrköping and Malmö revealed some of the freight rates. Since Foder and Cerealia contained rates from the year 2008 and forward, it was no point of using the few rates that were found from before 2008. From 2008 and forward, there were in total 1466 observations of which 977 had no information of destination and 256 were domestic freights; which were out of scope for the master thesis. The 233 freights that could be included for the period of 2008 until November 2010 were compared to the 977 that could not be included, and the conclusion was that the observations included were a good enough representation of the whole set.

5.4 Cost factors

Costs for ships are, according to our study, divided into fixed and variable costs and they are about equal.[76,77] The costs should be seen from a shipowner's perspective. Besides the freight rate, a demurrage fee is normally included in an offer. The demurrage states the compensation the shipowner will invoice for a standstill inflicted by the transportation purchaser and is often

---

[76] (Shipowner, 2010)
[77] (Stopford, 2009)

expressed in days. Fixed costs are usually close to the demurrage of a ship, the demurrage being slightly higher.[78]

5.4.1 Fixed cost

Fixed costs are insurance, crew salary, stores and supplies for the crew, interest rates, depreciations, maintenance, commission to shipbrokers, commercial management, technical management, book keeping and audit (see Table 6 on page 37). The insurance cost is mainly dependent on the age, value and condition of the ships: the higher value and worse condition of the ship, the more expensive is the insurance. Maintenance costs are dependent on condition and size: the worse condition and larger ship, the more expensive is the maintenance cost. The rule of thumb is that older ships have higher maintenance cost and lower insurance cost compared to newer ships of equal size. The cost for crew salary is dependent on the size of the crew. The minimum size of the crew for a ship depends on the size of the ship and where the ship is registered, since different countries have different regulations for minimum crew size. In general it is true that larger ships need to have more crewmembers. The cost for stores and supplies for the crew is directly connected to the crew size.[79,80, 81]

Capital costs are dependent on the carrying amount of the ship and the current interest rate. It also depends on the depreciation method used. In general, older and smaller ships have a smaller carrying amount and hence smaller capital costs compared to newer and larger ships.[82,83]

The cost for commission to shipbrokers is usually a percentage of the freight rate times the amount of goods shipped. Commercial management is the cost for making sure the ship has goods to ship. Technical management is the cost for administration and support to the ship, such as paying salaries, handling invoices and administrate maintenance.[84]

5.4.2 Variable costs

The variable costs are: bunker fuel costs, port- and waterway fees (see Table 7 on page 37). Fuel for ships is called bunker fuel, and the cost for bunker fuel makes up roughly 20 % of the total cost for operating a ship. Port fees often consist of two parts, where the shipowner has to pay one and the owner of the goods the other. The port fee for the shipowner is often based on the size of the ship or the amount of goods loaded or unloaded. The same is true for waterway fees, which consists of canal fees and fairway fees.[85]

5.5 Demand and supply factors

The factors affecting demand and supply that were found in this study are presented here.

---

[78] (Shipbroker, 2010)
[79] (Shipbroker, 2010)
[80] (Shipowner, 2010)
[81] (Stopford, 2009)
[82] (Shipowner, 2010)
[83] (Stopford, 2009)
[84] (Shipowner, 2010)
[85] (Shipowner, 2010)

5.5.1 Supply

The nature of supply is that it is rather smooth on a medium to long perspective and highly irregular in a short perspective when looking at a specific geographic area. For larger areas the supply is smooth and does only vary with the number of: newly built ships, ships sold to different markets, ships scraped and ship laid up (see Table 8 on page 38). In the short perspective this statement represent the nature of the market: "The supply is highly irregular in a specific area for the so-called tramp market. It is a week-to-week, or even day-to-day, basis."[86] The supply of ships in a specific area is totally dependent on the position of ships in a short time perspective.[87]

5.5.2 Demand

The nature of demand is more irregular and volatile than the supply, but demand has the same characteristics independent of perspective. Factors affecting the demand are the deep-sea freight rates, world economy, Chinese import/export activity, industries producing dry bulk commodities and the price of those commodities (see Table 9 on page 38 for a list of industries and commodities). Industries can have an effect on a local market if they are global, local close to the local market or even local in another part of the world. For commodities it was said that the higher the value of the commodity shipped, the higher the freight rates are.[88, 89]

5.6 Tables of factors affecting the freight rates

This section contains tables of the different cost, demand and supply factors that was found during the data collection.

Table 6: Fixed costs for operating a ship

Code	Candidate Factor Name
CF1	Insurance, depends on condition and value
CF2	Crew salary, depends on ship size and country of registration
CF3	Store and supplies for the crew
CF4	Capital cost: Interest rate
CF5	Capital cost: Depreciations
CF6	Maintenance; depends on age of ship. Roughly 1.5 Million SEK per year
CF7	Commission to shipbrokers
CF8	Commercial management, if outsourced: ≈250kSEK per ships & year
CF9	Technical management if outsourced: e.g. ≈250kSEK per ships & year
CF10	Book-keeping
CF11	Audit

Table 7: Variable costs for operating a ship

Code	Candidate Factor Name
CV1	Bunker (roughly 20 % of total costs)
CV2	Port fees (includes berthage, piloting, towing, sanitation and handling of tows)

[86] (Shipowner, 2010)
[87] (Shipbroker, 2010)
[88] (Shipbroker, 2010)
[89] (Shipowner, 2010)

CV3	Canal fees
CV3	Fairway fees

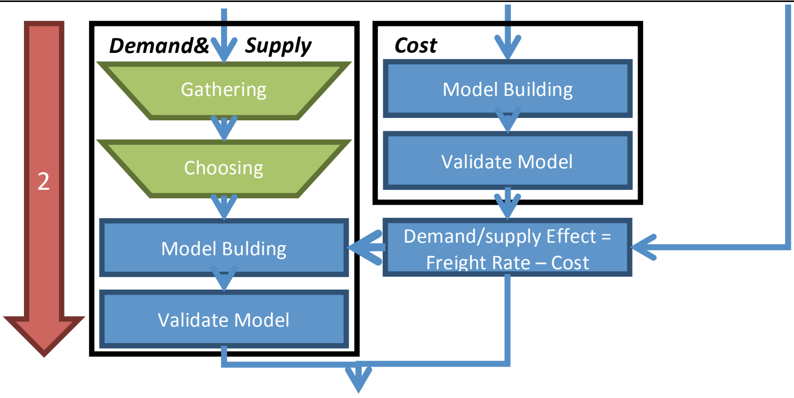
Table 8: Factors affecting the supply of ships available

Code	Candidate Factor Name
S1	Number of new built ships
S2	Number of ships sold to different market
S3	Number of ships scrapped
S4	Number of ships laid up

Table 9: Factors affecting the demand for sea freights

Code	Candidate Factor Name
D1	Deep sea freights (e.g. Handymax, Capesize, Panamax, 2-3 or 6 months delay)
D2	World Economy Growth
D3	Chinese Import/Export Activity
D4	Steel Industry
D5	Coal Industry
D6	Energy Industry
D7	Mineral Industry
D8	Wood Industry
D9	Wind Power Industry
D10	Agriculture Industry
D11	Construction Industry
D12	Other Industries
D13	Grain Price
D14	Ore Price
D15	Coal Price
D16	Cokes Price
D17	Scrap Metal Price
D18	Fertilizers Price
D19	Stone Price
D20	Salt and Minerals Price
D21	Wood Price
D22	Other Commodity Prices

6 Step 2 – Model development



The second step out of three of the research process of this master thesis was to develop the model. This was done by first analyzing the collected information from Step 1 and find corresponding time series for the cost, demand and supply factors. Second, a cost model was created and validated to be able to normalize the freight rates. Third, using the normalized freight rates from the cost model the demand & supply model was created and validated.

6.1 Analyze the data

One of the main assumptions made earlier was that two parts could describe the freight rates. Those parts are cost and the current market situation, the later referred to as the demand vs. supply situation. To test if this assumption holds an analysis of the sea freight industry, using Porter's five forces framework, was carried through. Another assumption was that the demand vs. supply situation could be described by existing time series. To evaluate this assumption a macroeconomic PESTEL analysis was performed. Finally the findings from the interviews indicated that there might be a difference in market structure for shipping in to the Baltic Sea and out from the Baltic Sea. An analysis of the difference between these two flows was therefore required. The results from these analyses are presented in this section.

6.1.1 PESTEL analysis

The macroeconomic factors that were found during the qualitative process of collecting data, from literature and interviews, can be sorted into the PESTEL framework. The table below (Table 10) shows for example that the infrastructure policies, which has a long-term effect on the freight rates is included in the political section of the framework.

Table 10: Macroeconomic factors in the PESTEL framework

Political	Economical	Sociocultural	Technological	Environmental	Legal
- Government Stability - Infrastructure policy	- Economic Growth - Interest Rates - Inflation Rate - Commodity Prices - Industry Growth - Bunker Prices	- Environmental Consciousness	- R&D activity	- Emission Regulations - Weather & Climate Change	- Employment Law - Safety Regulations - Anti-Piracy Campaign

The continuation of this master thesis consists of creating a quantitative model of the freight rate by using Regression Analysis. Since only quantitative explanatory factors can be included in a regression model these have been identified and underlined in Table 10. In this case it is only the economical factors that can be used. However, since there are a lot of complex connections on the macroeconomic level it is highly possible that also other non-economical factors included in Table 10 are affecting the quantifiable economical factors, giving the factors extra information that can be used by the model. The main result from the PESTEL analysis is that there exists quantitative explanatory factors, which can be represented by time series, that are likely to affect the demand vs. supply situation.

6.1.2 Five forces

The industry of supplying dry bulk freight in the tonnage size and region where Lantmännen is active, is analyzed by using Porter's five forces method. The perspective of this analysis is hence that Lantmännen themselves are a customer among others, shipbuilders and yards are suppliers and the industry competitors are shipbrokers, charterers and shipowners. A strong force is therefore indicating a tough competitive environment for the shipbrokers, charterers and shipowners.

Table 11: Microeconomic factors in the five forces framework

Bargaining Power of Suppliers	Threat of New Entrants	Rivalry among Industry Competitors	Threat of Substitutes	Bargaining Power of Customers
- Sensitive to business cycles - Few suppliers - Limited flexibility - Decreasing number of suppliers for small ships	- Long-term relations and experience important - Few regulations - High capital requirements (for shipowners)	- Many actors - Non-differentiated service - Fixed capacity - High exit barriers	- Environmental, Volume & Price advantages for shipping	- Low transparency - No opportunity to integrate backwards - No/low switching costs - Percentage of costs - Low value products

The **suppliers** in the industry are very sensitive to business cycles and the overall economy. When there is a high demand in the market their order books are full but in weaker economical periods very few ships will be ordered. Considering the high capital requirements to become a ship builder the suppliers are rather few and big and the number of suppliers for ships under 3 000 DWT are decreasing.[90] The capacity is limited in the sense that there are a fixed number of ships that can be constructed at one time. A lot of capital and time is required to increase the capacity, which makes the suppliers inflexible and even more sensitive to business cycles.

New entrants can in this perspective be both shipowners and shipbrokers. Generally the entry barriers consist of a need to have long-term relations and experience to be successful in the

[90] (Shipbroker, 2010)

industry. For shipowners there are also large capital requirements to purchase the actual ship. However there are few regulations hindering a new entrant in the industry.

There are many **competitors within the industry**, most of them small companies. Since dry bulk shipping is a very basic service there is a low level of differentiation between the competitors, this means that price competition is most common. However there are exit barriers both in the form of tied capital in ships and of specific know-how that only to a small extent can be applied in other industries. The amount of ships is rather fixed, which limits the capacity and makes the industry very sensitive to business cycles.

There are few realistic **substitutes** for shipping that has similar benefits when it comes to high volume, low price and low negative environmental related effects. However there are substitutes with a higher rate of flexibility, e.g. trucking. Shipping is especially strong when looking especially at the geography of Northern Europe and the Baltic Sea.

The **customers' bargaining positions** are strengthened by the fact that there are low switching costs, partly because of the fact that a lot of the contracts are agreed are one time deals but also because of the undifferentiated service. Many customers are active in rather basic industries and are shipping low value products, and since the percentage cost of the shipping is rather large they have strong incentives to put pressure on the price. However the customers' bargaining positions are weakened by the fact that there are a very low transparency and that the customer has a limited possibility or desire to integrate backwards.

Adding up the five forces, and putting more weight on the internal competition the overall competitive environment of the industry can be assessed. However this assessment must be made with respect to the current economical circumstances. In times of recession and low economical growth the competition is very tough, while in good economic times there is plenty of business for everyone with good profit margins. The most important conclusion however is that the only mean of competition is through price, since there are few possibilities of differentiation. This implies that the price could be viewed as the cost plus a profit margin, the profit margin depending on the current economical circumstances, or the demand vs. supply situation.

6.1.3 Difference between North-South and South-North flows

As described in the earlier chapter 5.1, there are more goods being transported from the Baltic Sea area (North-South) relatively to the amount of goods being shipped in the opposite direction (South-North). This imbalance means that there are more competition and hence lower freight rates for ships temporarily in the South-North flow. For Lantmännen, Foder represents a typical South-North flow while Cerealia DK and Spannmål have a North-South oriented flow.

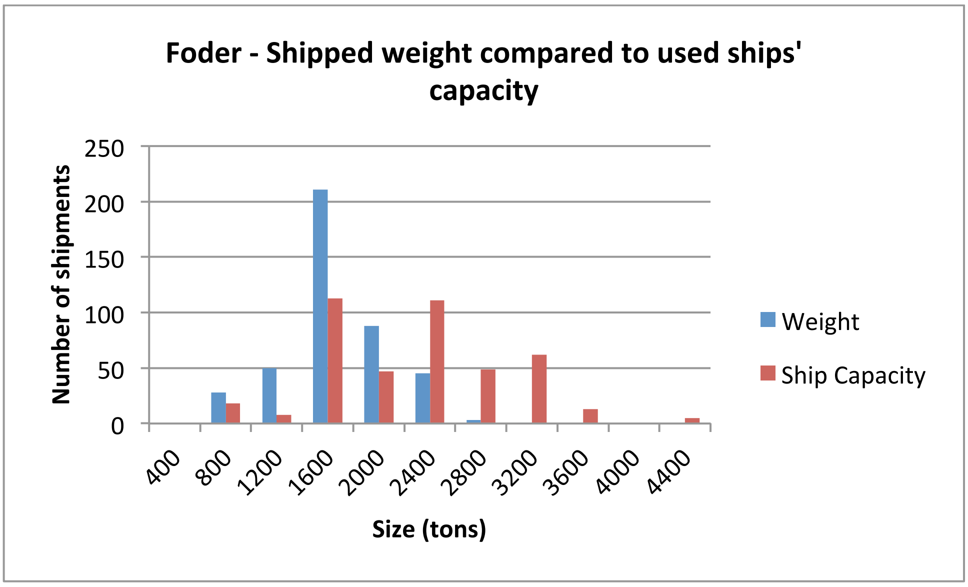


Figure 14: Shipped weight compared to used ships' capacity for Foder.

The above Figure 14 is a histogram of Foder's goods weight (blue) and the maximum loading capacity for the ships used (red), divided into intervals of 400 ton. There is a clear shift between these two statistics, indicating that a lot of ships used by Foder had unused loading capacity. This deduction is supported by the fact that the average fill rate of the ships used by Foder only was **77 %**.

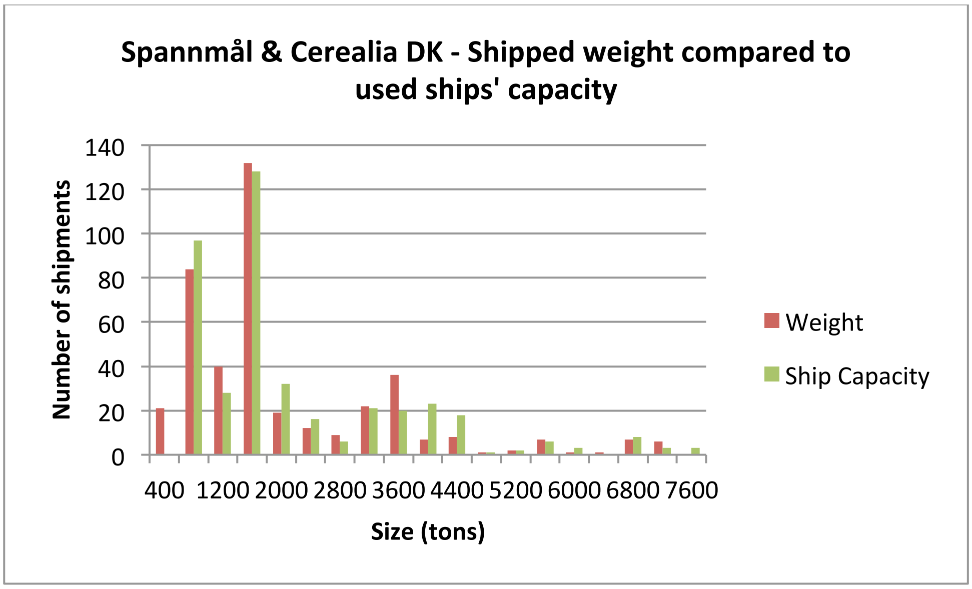


Figure 15: Shipped weight compared to used ships' capacity for Spannmål & Cerealia DK.

The above Figure 15 displays the corresponding statistics as Figure 14 for Spannmål and Cerealia DK. Compared to Foder, there is no clear shift between the weight of the goods and the ship's capacity. Instead, there seems to be a better matching between the ship's capacity and the cargo weight. The average fill rate for Ceralia DK and Spannmål is **91 %**, which is considerably higher than 77 % for Foder.

Because the results from the data collection and the analysis above indicated differences between the structures of the North-South and South-North flows, further investigations were made. For the North-South route the ships on average were full or close to being full, this is represented by the blue line lying close to the red line in Figure 16. There was also a clear trend that larger ships get higher average revenue per day than smaller. This result is in parity with the theory since the larger ships have a higher capacity and can thus load more tons, they also need a higher revenue to cover higher costs.

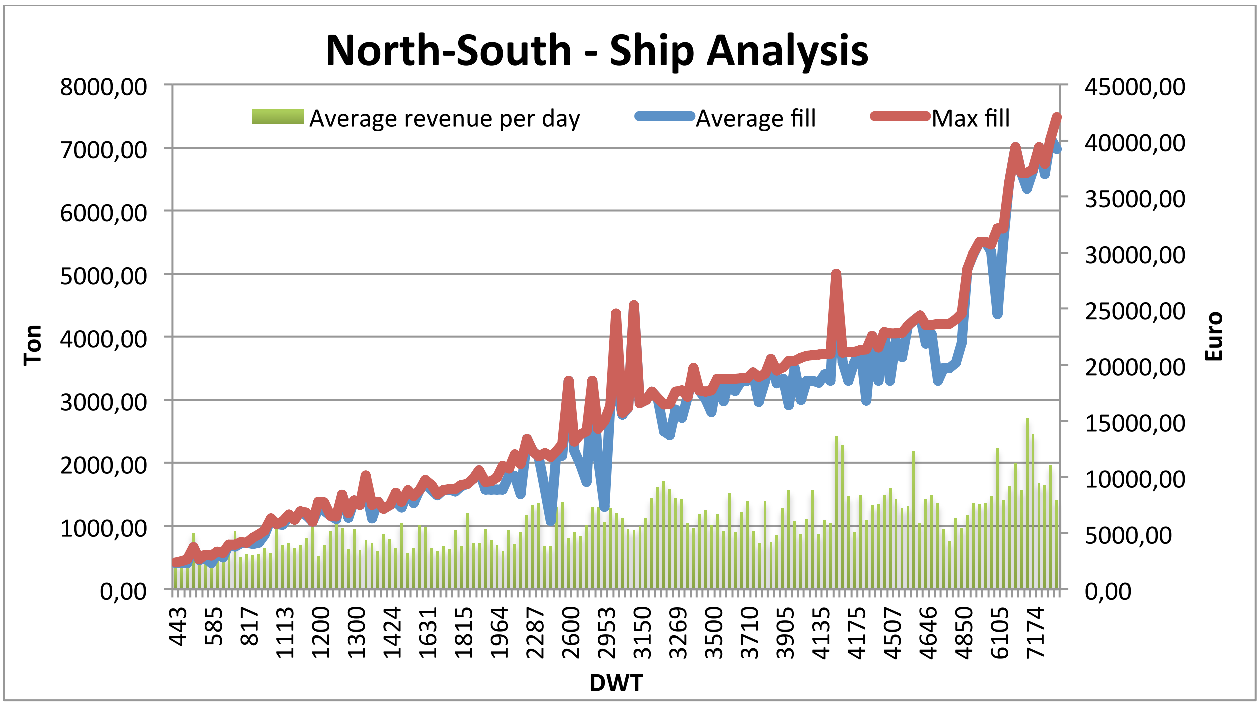


Figure 16: Analysis of ships fillrate and revenue for North-South directed freights.

For the South-North route the larger ships were not as full as for the North-South route, represented by the divergence of the blue and red line in Figure 17. This can be explained by the fact that Lantmännen on this route are shipping feed goods directly to their factories, and since the factories have a fixed storage room the amount of goods that is shipped is limited. The investigation showed that Lantmännen have mainly been shipping about 1500 to 2000 tons on this route, even if the ship had a much higher capacity. Also, contrary to the North-South route, larger ships do not get higher daily average revenue, which is indicated by the fact that the green bars are rather even over all ship sizes in Figure 17. This is highly likely because of the imbalance of flow and that ships have to accept lower revenues in the South-North direction.

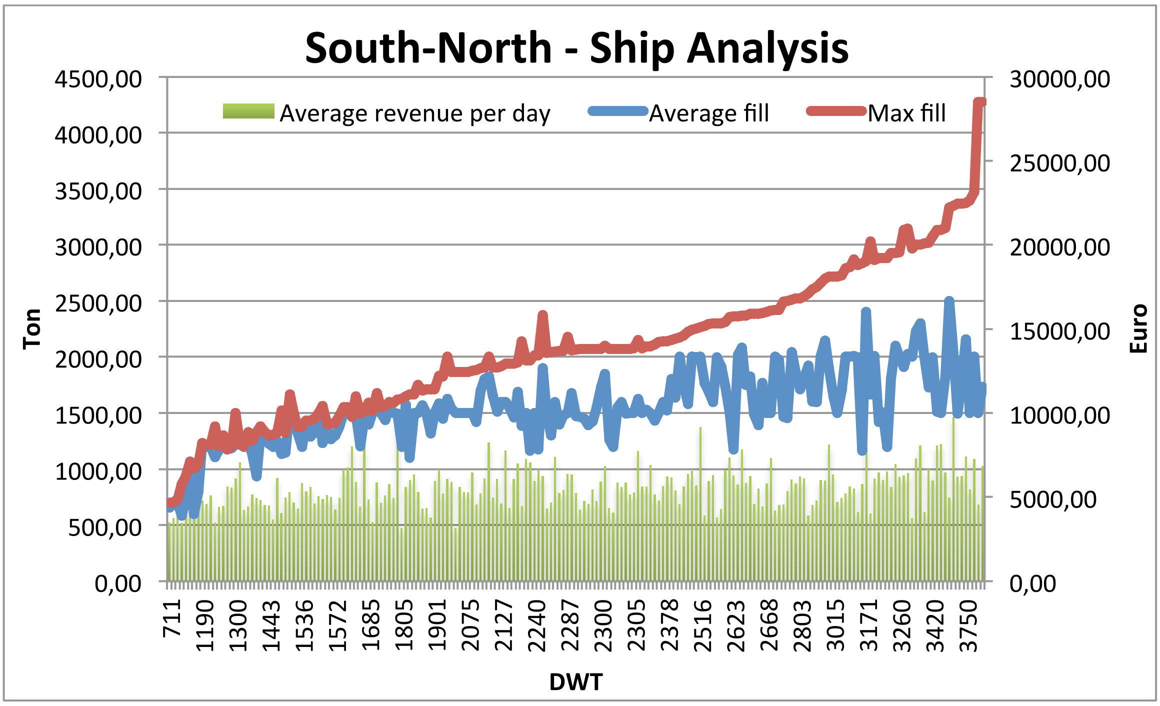


Figure 17: Analysis of ships fillrate and revenue for South-North directed freights.

The results from the investigation are additional confirmations on the previously discussed differences between the North-South and South-North routes, which further strengthens the validity of the choice to treat the two routes separately. Hence two different demand & supply models had to be created. However, the cost model could still be the same for both flows, since the differences only exists on the revenue side without any effect on the actual costs for the ships.

6.2 Creating the structure for the model

The overall approach for model structure was to first define the part of the freight rate that describes the ship's costs and then to use regression analysis to model the part of the freight rate that depends on the balance between demand and supply. Hence the freight rates were normalized from cost effects and the remaining demand and supply effect of the price was modeled with a multiple regression model. The below scheme describes this process:

1. **Cost normalize** the Freight rates by using:
    a. Ship Classification – describes the cost structure for a ship of a specific size.
    b. Port Classification – describes the cost structure for a freight between two specific ports.
2. Fit **Multiple regression demand & supply models** to the normalized freight rates using
    a. Indices as explanatory variables for demand and supply
    b. Different time lags of the indices to create ability to forecast for 3 and 6 months
    c. Different models for the North-South and the South-North routes

   In total, four demand & supply models are created, North-South 3 month, North-South 6 month, South-North 3 month and South-North 6 month.

6.2.1 Assumptions for the model structure

The main assumption behind this model structure is that the demand and supply structure is equivalent for different flows within each of the two main routes, i.e. all flows within North-South has an equivalent structure (e.g. Stockholm-Cadiz has the same demand and supply balance as Helsingborg-Amsterdam). This may not be entirely true, but since the model only are to forecast transports to or from Sweden the assumption is reasonable, since ships will move where the pay is best and then the supply will increase and the rates drop until the profit margin is on a similar level.

Another important assumption (already mentioned in 6.1.3) was that since there exist imbalances between the North-South and South-North routes, these flows should be viewed as different and also modeled with different regression models.

Many of the costs are dependent on numerous factors that are specific to each ship, port and route. Since it would have been too much work to gather the exact costs for every ship on every route from and to every port, assumptions regarding costs have been made. The first cost assumptions are regarding the ships: ships within a specified size range (defined by DWT) are assumed to have most costs equal. It is also assumed that all ships have the same profit per day and ton. Implying that there exists economies of scale for larger ships. Because of how cost calculations for ships were done, ships with DWT below 400 were excluded, however only one ship of the 392 had a DWT below 400. This ship was also the oldest ship by far, being more than a hundred years old and was hence considered to have different cost structure.

Assumptions were also made for costs for towing and/or piloting, which are hard to calculate, because the regulations are very different in different areas and also dependent on unknown factors, such as the ship captain's competence and the current weather conditions. The only piloting costs that are included in the model are the ones being charged for ships entering canals and ports were piloting was mandatory. Another important cost is the cost for fuel, or bunker. This is dependent on the consumption, which is specific to each ship and varies with speed, size and age. Speed and the bunker consumption were calculated based on an investigation of roughly 100 boats. However the investigated ships were not always ships used by Lantmännen, thus an necessary assumptions was that equally sized, and aged, ships have similar fuel consumption and service speed.

Further assumptions regarding costs were that the port costs ,used in the cost model, were assumed to have been the same during the last two years. This assumption was made because of non-existing records of historical port costs. Also, in those cases when the port costs were unobtainable, the port cost of the nearest port in the same country was used. Another port specific feature that affect the costs is the loading and unloading capacity of the port, this together with the type of cargo affects the loading and unloading time. Based on the interview results, but also practical concerns regarding the model, an assumption was that the unloading and loading times are independent on the type of cargo that Lantmännen shipped. Another assumption made, was that loading and unloading speed is the same for all ports.

The current weather and especially the ice situation have an effect on the freight rates. However, this information is hard to implement into a model without dramatically increasing the complexity level. Therefore weather effects and the ice situation was not included.

Other assumptions that were made when creating the ship- and port classifications are described in Appendix C and D, respectively. All assumptions made are in line with interviews made and literature studied throughout this master thesis. Hence, it should not have any apparent effects on the results. In fact, a model is a simplification of the reality, and in this case the simplifications are reasonable and logic. There might be a loss of generality because of the assumption that routes in the same direction are expected to have the same market structure. This means that if this assumption is incorrect, i.e. the market structure is in fact entirely different for different routes in the same direction, the model will not be able to forecast accurately.

6.3 Cost model

The goal of the cost model is to normalize the freight rates so that all freight rates can be compared, independent of the distance of the freight, the cargo weight and the ship size. The idea behind this approach is two folded. First, there were not enough data to perform a significant analysis on only a limited number of routes. Second, it is the demand and supply effects that determine the market balance and a large part of the offered freight rate, at a specific moment. In the original data set of freight rates this demand and supply effect was in large parts hidden by cost effects: related to the specific distance of a route, the cargo weight and the type of ship.

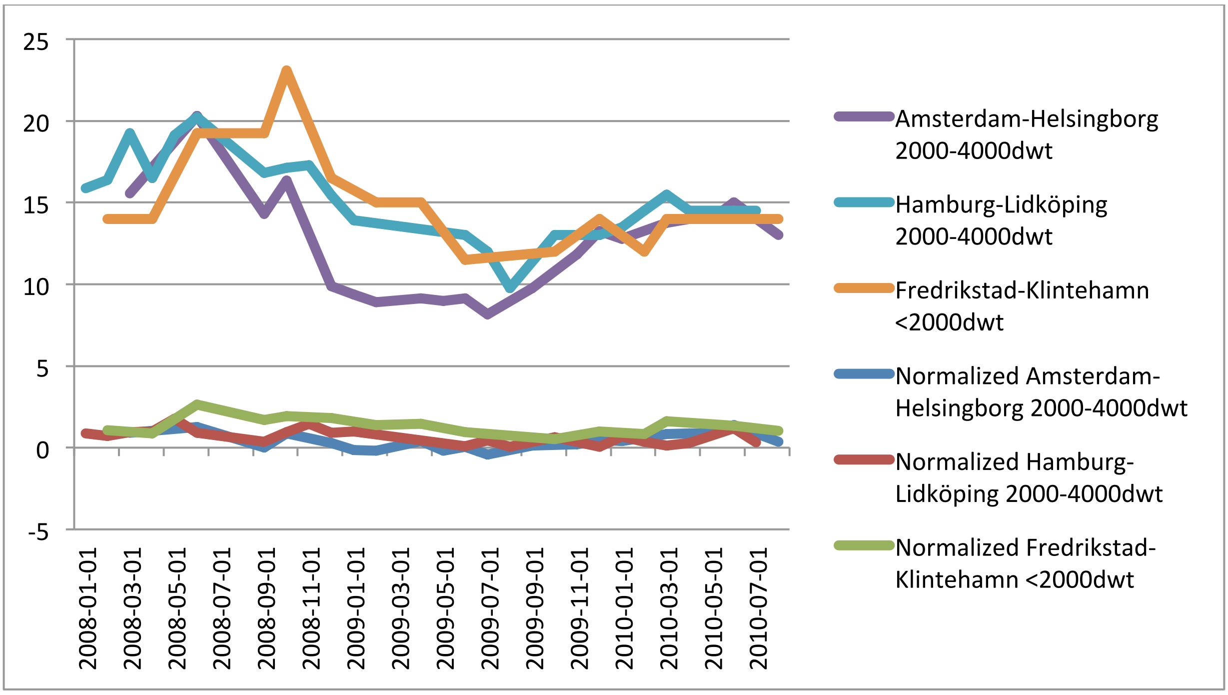


Figure 18: Example of normalization of freight rates.

The above figure (Figure 18) presents an example of how three series of freight rates have been normalized by deducting the cost part of the freight rates. After the normalization (the three lines in the lower part), where all costs has been removed, the rates can be easily compared, and together they make up a description of how the demand and supply effect have changed during the last years.

In order to succeed with the normalization two classifications had to be made; the *Port classification*, describing costs related to the specific ports being used and the route between the ports, and the *Ship classification*, describing the cost structure for ships of a certain size.

In order to normalize the freight rates knowledge of how to model each of the costs were needed. A mapping of how to model each of the costs identified and presented in chapter 5.6 were done. The result was that all costs could be described by the "Ship classification" and the "Port classification" together with the interest rate and a bunker price index (see Appendix D for details). This is presented in Table 12.

Table 12: Cost factors and what they are modeled by

Code	Candidate Factor Name	Modeled by
CF1	Insurance, depends on age and value	Ship classification
CF2	Crew salary	Ship classification
CF3	Store and supplies for the crew	Included in CF2
CF4	Capital cost: Interest rate	Ship classification and interest rate
CF5	Capital cost: Depreciations	Ship classification
CF6	Maintenance	Ship classification
CF7	Commission to shipbrokers	Included in CF8
CF8	Commercial management	Ship classification
CF9	Technical management	Ship classification
CF10	Book-keeping	Included in CF9
CF11	Audit	Included in CF9
CV1	Bunker	Bunker index
CV2	Port fees	Port classification
CV3	Canal fee	Included in CV2
CV4	Fairway fee	Included in CV2

6.3.1 Port classification

The port classification contains information about all the ports that Lantmännen used during the studied period and their respective orientation towards one another. The port classification is built of three components; the first is a list of ports and the fees associated with entering the port. The second component is a list of distances between all ports, and the third is a list of costs between all ports, depending on canal fees.

The list of ports contains information of each port's fees, information that was collected through webpages, email and telephone contact with the specific port companies. The diverse standards of different countries are incorporated to allow the port fees to be as similar to the reality as possible. In total there were 82 different ports included in the classification.

Table 13: Example of Port classification

List of ports	Fee per GT	2nd Fee per GT	1st Threshold	3rd Fee per Gt	2nd Threshold	Fee per Cargo ton	Cu
Aalborg	2,25	2,76	5001	3,28	10001		DKK
Amsterdam	0,291					0,467	E

The above Table 13 is an example of some of the port fees that were collected and incorporated into the cost model. However, in the list used there were many more columns to define all the different calculation rules that were used by the studied ports. At the port of Aalborg the fee is dependent only upon the gross tonnage (GT) of the ship. Ships having a GT of 5000 or less have to pay a fee of 2,25 DKK per GT, a ship with GT of between 5000 and 10 000 have to pay 2,25 DKK up to 5000 GT and 2,76 DKK for the rest. For GT over 10 000 the fee is 3,28 DKK; as an example a ship of 12 000 GT have to pay 2,25 $DKK \times 5000 + 2{,}76\ DKK \times 5000 + 3{,}28\ DKK \times 2000 = 31\ 610\ DKK$ in the port of Aalborg (see Table 13). For Amsterdam however the fee is also dependent on how much cargo the ship is holding; 0,291 Euro per GT plus 0,467 Euro per ton of cargo. A ship of 12 000 GT could therefore cost more or less depending on cargo weight; as example a ship of 12 000 GT with cargo of 10000 ton have to pay fees of $0{,}291E \times 12\ 000 + 0{,}467E \times 10\ 000 = 8162\ E$ when using the port of Amsterdam (see Table 13). Since most fees were stated in local currencies exchange rates were needed to translate the fees into Euro. The complete list of ports can be seen in Appendix D.

The list of distance contains information of how the different ports relate geographically to each other, it is used to calculate the distance between all ports, the closest route, the canals that will be used etc. This information was extracted using the tool Google Earth© (see Figure 19).

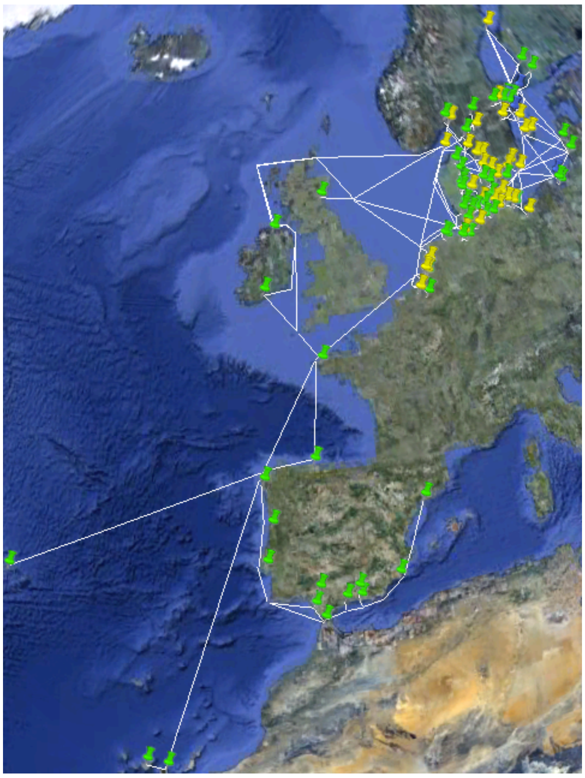


Figure 19: Screenshot from Google Earth © showing the ports and routes used.

The canal costs were acquired from homepages of the different canal operators.[91, 92] Those costs are dependent on ship size and hence this information is associated with both the ship classification and the port classification. The cost was calculated for each canal and ship class and information from the list of distances was used to check if a canal was travelled or not.

6.3.2 Ship classification

The ship classification is a list of different sizes of ships measured in DWT, in total 10 different ship classes where used. The list holds information about the crew size, the booked value of the ships, maintenance costs, about fees for commercial management, fees for technical management, bunker consumption, loading and unloading speed, canal fees and the speed of the ships (see Table 14 for a short extract). Those facts were acquired through interviews, literature and various webpages, for details and the full ships classification see Appendix C.

Table 14: Extract of the ship classification

Class	Low DWT	High DWT	Crew Size	Yearly Crew Salary (incl. tax and social fees) €/year	Maintenance €/year	Insurance €/year
1	400	1200	4	48000	90000	10000
2	1201	1600	5	47250	100000	30000
3	1601	2400	6	46875	110000	40000
4	2401	3000	7	46500	120000	50000
5	3001	4000	8	45750	150000	70000
6	4001	5000	9	45000	160000	85000
7	5001	6000	10	44250	180000	100000
8	6001	7000	11	43500	195000	110000
9	7001	8000	12	42750	205000	120000
10	8001	9000	13	42000	220000	130000

Since DWT was used to determine which ship class a ship belonged to and this information was not available an investigation had to be made. The result was a list of the 392 ships used by Lantmännen during the last few years. This list contains the name, the DWT, the GT, the age and the flag of each of the ships. This list was also used to calculate port fees, since they were often dependent upon GT. See Appendix E for this list.

6.3.3 Acquire indices

For the cost model, there were three types of different time series needed to accurately calculate the costs in different time periods. These were interest rates for the calculation of capital costs, bunker price to be able to calculate fuel costs and exchange rates to be able to

---

[91] (Sjöfarsverket)
[92] (Kiel-Canal.org)

translate all costs into Euro. The interest rate that was chosen to represent the interest based part of the capital costs of the ships was the "Euro repo benchmark 3 months". This choice was based on the fact that the majority of the ships used by Lantmännen are from various European countries. The bunker price that was chosen to represent the bunker cost was "Bunker Oil, 180 cst, Rotterdam U$/MT", an index based on the price for bunker oil in Rotterdam, a large hub for shipping in the Northern Europe region. All exchange rates that were needed was collected, e.g. to be able to exchange all port fees to Euro. See Table 15 for a summary of the time series needed for the cost model.

Table 15: Information to model costs and indicators

Type of information	Costs modeled	Indicator – time series	Comment
Interest rate	Capital costs (CF4)	Euro repo benchmark 3 months	To calculate interest rate related costs at different time points
Bunker price	Bunker costs (CV1)	Bunker Oil, 180 cst, Rotterdam U$/MT	To calculate the bunker cost at different time points
Exchange rates	na	16 Exchange rates	To be able to exchange all non-Euro fees/costs at different time points

6.3.4 Creating the cost model

The cost model was applied on Lantmännen's historical freights. The first step was to adjust for the fact that all ships were not fully loaded with cargo. This was done by investigating how much each ship at maximum had ever carried, and use this number or 90 % of the ships DWT, whichever was higher, and adjust the rate to a level were the ship would have been fully loaded. This adjustment was carried out because of an interview finding stating that shipowners in most cases adjusts the freight rate, so that they in total get the same revenue as if they ship was full.[93]

From this adjusted rate all costs were deducted. The costs were calculated by using data about the ports, the ships and the date of shipment and then combine this with the port classification, the ship classification and the indices for bunker, interest rate and exchange rates. Finally the remaining part of the rate was divided by the shipment time to acquire a fully normalized rate per day and ton. This was done for all historical freight rates and resulted in a profit per day and ton figure for each and every shipment in the data set. The profit per day and ton is a figure that is relevant to compare between different shipments, since all route specific effects are removed. Hence, a route neutral demand and supply (market) effect can be extracted by studying how the profit per day and ton changes over time.

Example of cost model calculations

An example of the calculations performed by the cost model is presented in this section by using the shipment of 1060 tons of soy from Fredrikstad to Klintehamn the 10th of April 2008, for 14 Euro/ton. The ship used for this freight is named Via, which has a DWT of 1470 and a theoretical maximal capacity of 1347 tons. The total time spent on this freight was 4.1 days, with 2.7 days of travel time and 1.4 days in the two ports for loading and unloading operations.

[93] (Shipowner, 2010)

The freight rate of 14 Euro/ton was recalculated into 12.1 Euro/ton, by calculating the rate that the full ship would have charged. Then the freight rate for the full ship was divided by the number of days (4.1), leaving the freight rate per day as 2.94 Euro/ton. This transformation of the freight rate is illustrated in Figure 20.

Figure 20: Transformation from standard freight rate to freight rate per day for a full ship.

The freight rate per day was then split into costs and profit. The costs, all expressed in Euro per ton, were calculated as 0.04 in capital costs, 0 in canal costs, 0.12 in port fees, 0.55 in crew costs, 0.72 in bunker costs and 0.63 in other costs (e.g. maintenance). The remaining part of the freight rate per day, i.e. 0.87 Euro per ton, is the shipowner's profit. The cost breakdown is illustrated in Figure 21.

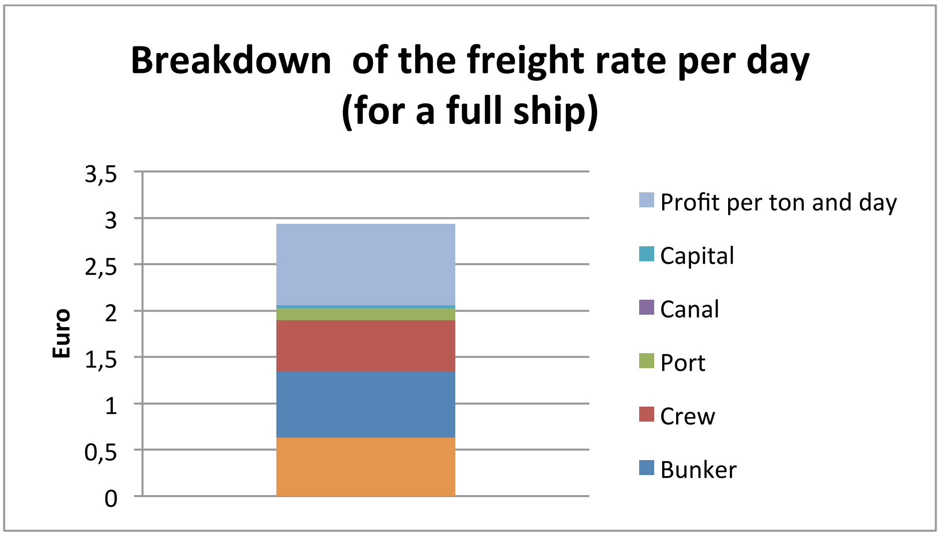


Figure 21: Breakdown of a freight rate per day for a full ship

Results of cost model

Since the purpose of the thesis was to create a price forecasting model, data on a detailed level was not required but rather larger movements. All historical freight rates were normalized in the same manner as presented in the example above; cost and profit per ton and day calculated for all freight rates. The part referred to as profit per ton and day being the fully normalized freight rate. Those normalized freight rates were then used to calculate an average normalized freight rate per month for each month and flow (North-South and South-North). The final results of the cost model were hence two time series of monthly averages of normalized rates, one for the North-South flow (see Figure 22) and one for the South-North flow (see Figure 23).

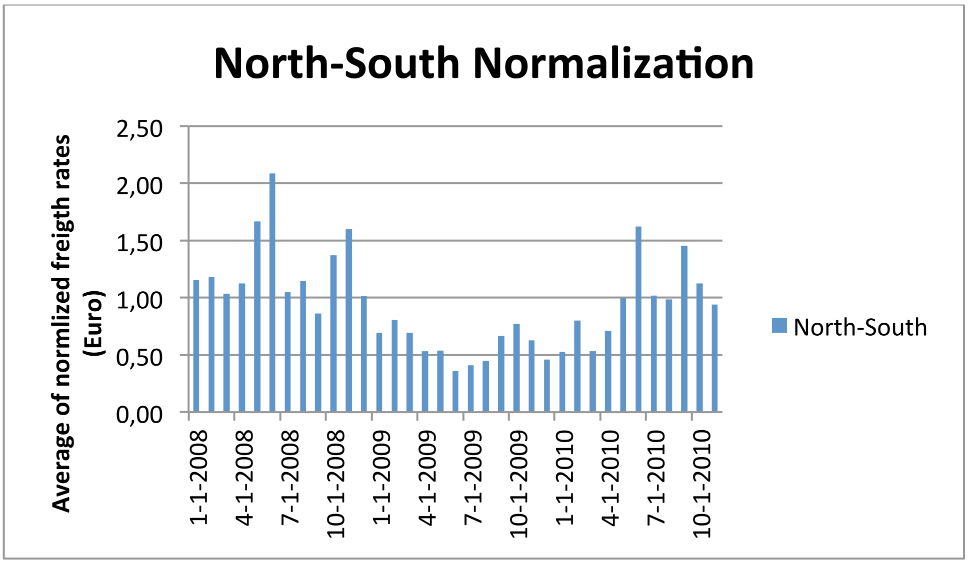


Figure 22: Normalized freight rates, average per month, for the North-South flow.

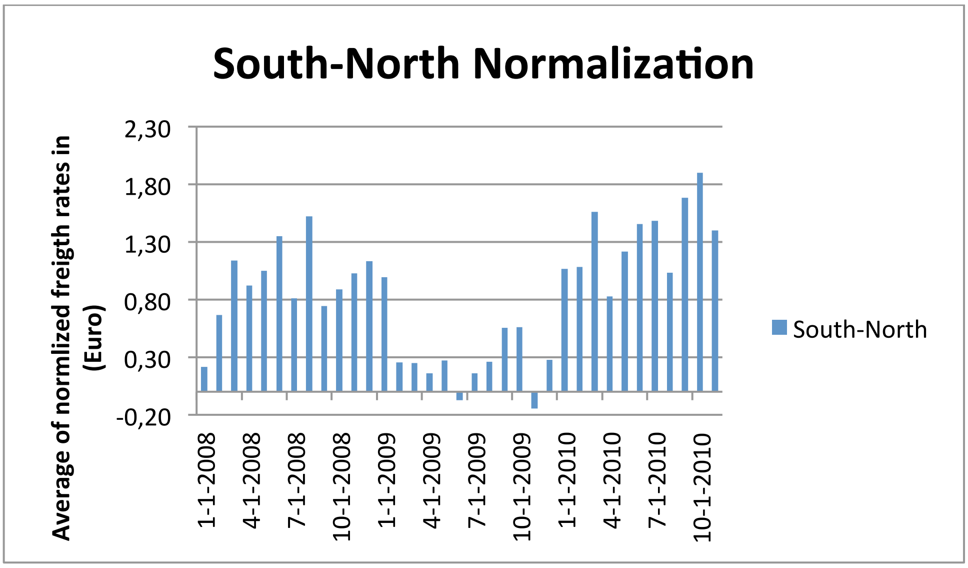


Figure 23: Normalized freight rates, average per month, for the South-North flow.

The two time series (shown in Figure 22: Normalized freight rates, average per month, for the North-South flow.Figure 22 and Figure 23) are hence representing the average profit per ton and day for the shipowners performing sea freight for Lantmännen.

For both of the flows we could see that there still existed too much short-term variance. Outliers and extreme months were observed for both the North-South, such as summer 2008 and 2010 (see Figure 22) and the South-North flow, for example summer 2008 and spring 2010 (see Figure 23). A five-month moving average was therefore applied to the model to decrease the impact of extreme months and outliers. The moving average smooth the demand and supply effect and displays the trend of the data. The effect of the moving average is hence that it decreases the impact of extreme events, e.g. in June 2008 for the North-South rates, and instead focuses on replicating to overall trend (see Figure 24). Also for the South-North rates a five-month moving average (MA5) decreases the extreme events, since the moving average mainly shows the overall trend (see Figure 25).

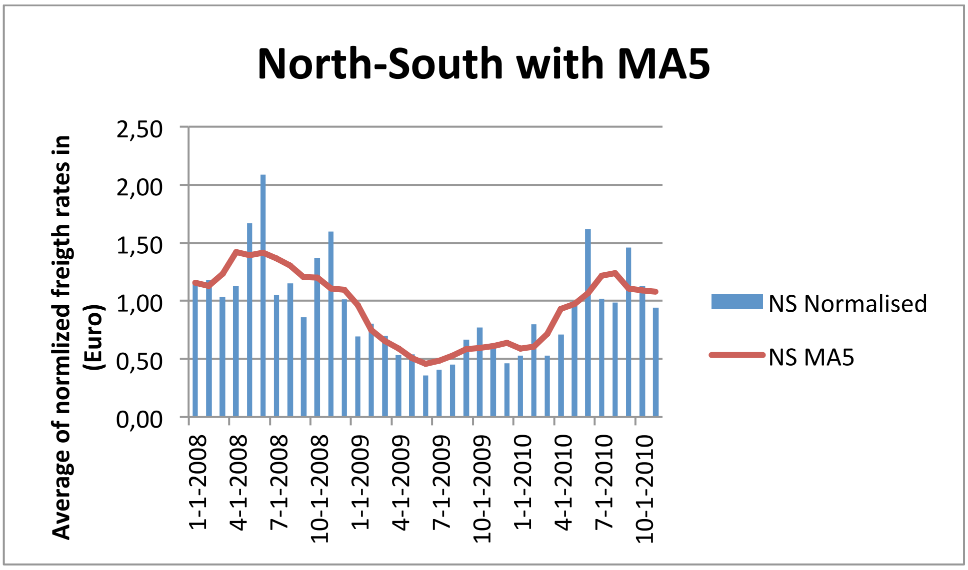


Figure 24: Normalized freight rates, average per month and MA5, for the North-South flow.

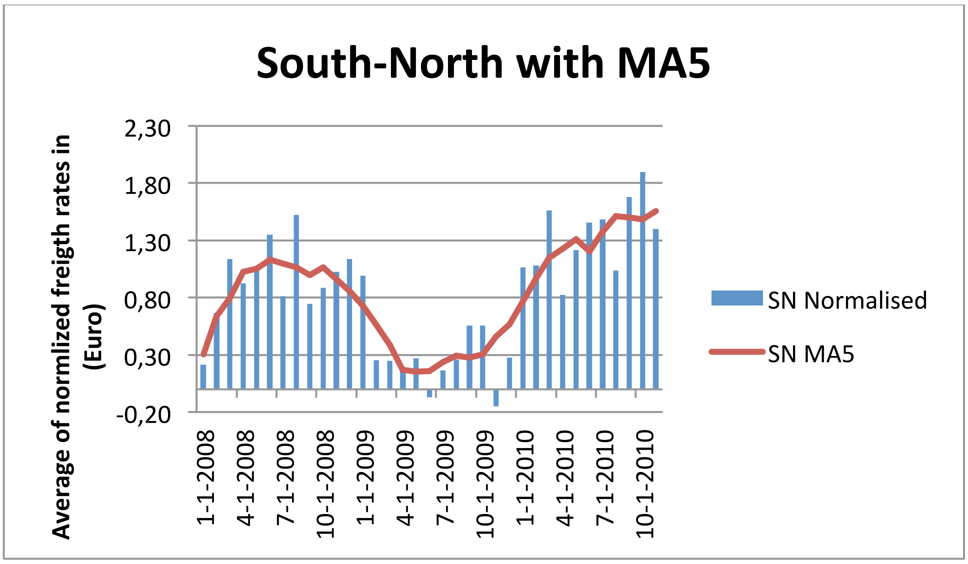


Figure 25: Normalized freight rates, average per month and MA5, for the South-North flow.

The demand & supply model was built using the two MA5 time series shown above as input. This is because the main focus of the model was to replicate the overall trend of the markets, which is enabled by taking less regard to extreme data. In the continuation of the thesis, when MA5 or input data is discussed, we are referring to the MA5 data presented in this chapter.

6.3.5 Validation of cost model

As a first step of validating that the cost model accurately calculates the costs for the ships a comparison between the fixed costs and demurrage was made. Demurrage is the fee that the transportation purchaser needs to pay if the ship is delayed, because of reasons that the transportation buyer is responsible for, e.g. a delay in the loading port because of the goods not being ready to load. This means that the demurrage should be an approximation of the fixed costs of the ship plus a profit margin.[94]

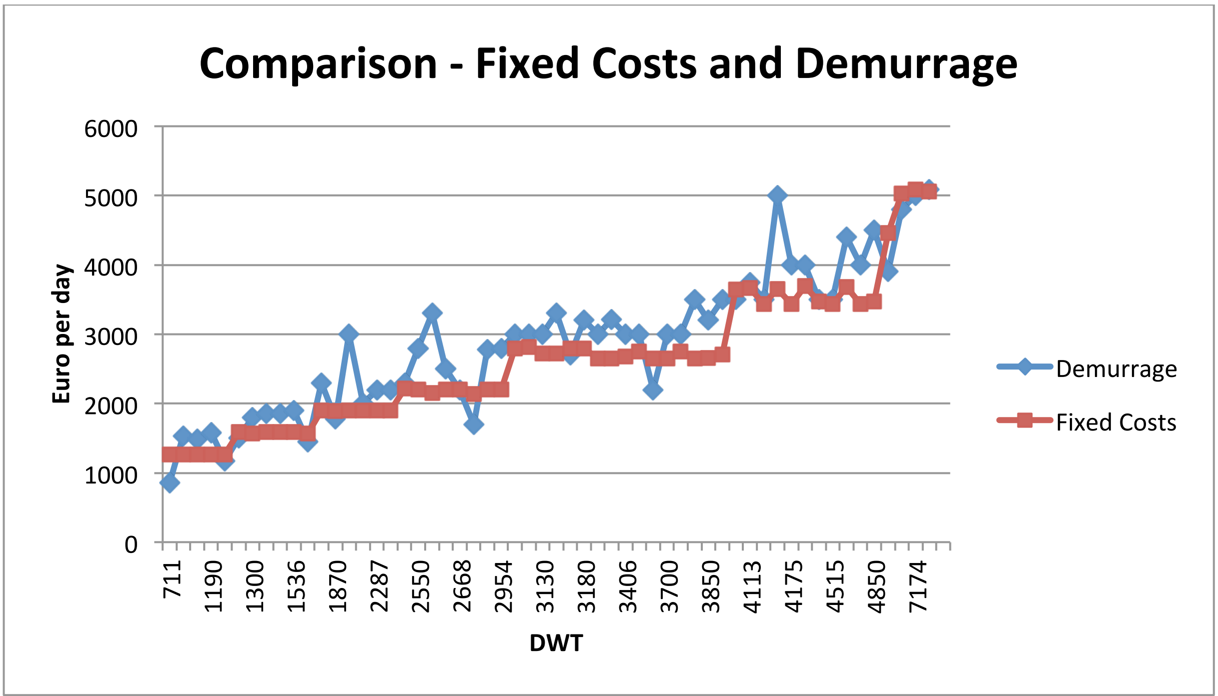


Figure 26: Validation of fixed cost by comparison to demurrage

Figure 26 above shows a plot of 56 ships sorted on DWT on the x-axis, with their given values for demurrage (blue) and the cost models calculation of their fixed costs (red). In the vast majority of the cases shown in the figure the demurrage is close to or slightly above the fixed cost. This validates that the fixed costs calculated by the cost model for these ships are in accordance with the finding from the interviews: that the fixed costs should be approximately equal or slightly less than the demurrage. However, it is important to realize that only 56 out of 392 ships had a listed demurrage fee. The demurrage investigation (Figure 26) shows good results for all ship sizes, and hence the fixed costs for the majority of the remaining 336 ships was assumed to have a corresponding high accuracy.

The overall validity of the cost model is also dependent on the accuracy of the variable costs. However, the variable costs have less complexity than the fixed costs since they are based less on assumptions and more on known relationships, i.e. between distance and bunker consumption, official port fees and listed canal fees. Bunker costs should be approximately one fifth of the total cost, depending on distance, according to interviews.[95] This condition was investigated and found true for the model.

---

[94] (Shipbroker, 2010)
[95] (Shipowner, 2010)

6.4 Demand & supply model

The demand & supply model is more straightforward compared to the cost model. All freight rates were normalized by the cost model and a multiple regression model is used to find the best indicators for the demand and supply effect, i.e. the MA5 data from the cost model. The first step was to summarize the potential factors and what type of indices they could be modeled by. The summary was done by first listing all factors, acquired from the data collection step. Secondly, the possible types of time series that could model those effects were identified. The result is seen in Table 16.

Table 16: Demand and supply factors and what they are modeled by

Code	Candidate Factor Name	Modeled by
S1	Number of new built ships	Indices for shipbuilding companies, indices showing new build ships
S2	Number of ships sold to different market	Fixed percentage of new built (S1) with delay, second hand market prices, local industry outlook
S3	Number of ships scrapped	Fixed percentage of new built (S1) with delay, scraping prices, metal prices, local industry outlook
S4	Number of ships laid up	
D1	Deep sea freights (e.g. Handymax, Capesize, Panamax)	Baltic Dry Indices (market leading indices for deep sea bulk freight)
D2	World Economy Growth	Macroeconomic indices for different parts of the world and leading economies
D3	Chinese Import/Export Activity	Chinese macroeconomic indices, Import and Export indices
D4	Steel Industry	Branch indices
D5	Coal Industry	Branch indices
D6	Energy Industry	Branch indices, Electricity Price
D7	Mineral Industry	Branch indices
D8	Wood Industry	Branch indices
D9	Wind Power Industry	Branch indices
D10	Agriculture Industry	Branch indices
D11	Construction Industry	Branch indices
D12	Other Industries	Branch indices, Stock Market Indices
D13	Grain Price	Commodity indices
D14	Ore Price	Commodity indices
D15	Coal Price	Commodity indices
D16	Cokes Price	Commodity indices
D17	Scrap Metal Price	Commodity indices
D18	Fertilizers Price	Commodity indices
D19	Stone Price	Commodity indices
D20	Salt and Minerals Price	Commodity indices
D21	Wood Price	Commodity indices
D22	Other Commodity Prices	Other Commodity indices

6.4.1 Acquire indices

For each of the factors a search was conducted in Thomson Reuters DataStream. By using search strings, constructed from the words in the summary of potential factors (see Table 16), a total of 190 indices were collected. The result is presented in Appendix A.

To avoid problems with instability in the model and to ease the process of choosing suitable indices, an initial cleanup, based on intercorrelation, was performed on the 190 variables. The method of the cleanup was to calculate the correlation between all combinations of index pairs and removing one index in the pair if their correlation was either close to one or close to minus one. The threshold used was 0,98 and-0,98, thus removing only the variables that had a very close relationship. This cleanup resulted in the removal of 22 variables, leaving a set of 168 potential variables for the regression.

6.4.2 Creating the demand & supply model

The goal of the this step in the process was to find a group of indices that in a good way described the historical normalized freight rates. In this case "good" is defined by qualitative and quantitative measures. The quantitative measures were mainly the goodness of fit, explained by the adjusted R-square value, but also the properties of the residuals; validating if the assumptions for the regression was fulfilled. The qualitative measure was a sense check to make sure that a combination of indices made logical sense and did agree with the theory from the qualitative part of the study. Since all those test were performed numerous times a test environment was built to ease the work.

The test environment's engine, the regression method, was based on the forward-with-a-backward-look stepwise regression method (see end of chapter 3.4.3). The method was applied on the first 28 months of MA5 data, ranging from January 2008 until April 2010. The rest of the MA5 data, i.e. May 2010 until November 2010, were later used to validate the model. This decreased the risk of creating an overly adapted model.

In further detail, the regression method was applied four times: on the North-South and South-North normalized data, first with all variables lagged three months, and secondly, with a six month lag. For each of the four models the properties of the residuals were illustrated with residual plots, autocorrelation test plots, heteroscedacity test plots and also the average of the residuals, Jarque-Bera and Durbin-Watson tests. The combination of indices suggested by the test environment was also critically observed, by the authors, so that the combination of variables made logical sense and did agree with the theory from the qualitative part of the study. If there were any inconsistencies the regression method was applied again, but now with the latest combination excluded from the set of possible combinations of variables.

It was desirable to keep the total number of indices as low as possible. Therefore tests were performed to evaluate if it was possible to use the same indices to model 3 and 6 months or to model North-South and South-North flow. The results indicated that it was impossible to find a set of indices that could model all four cases. However, it was possible to use the same set of indices for the North-South and South-North models with the same time lag. This choice will have a somewhat negative effect on the fit, but the winnings are greater. This since fewer indices leads to easier interpretation and less maintenance of the model. The costs associated with maintaining the model will also be lower. Also, using more than five indices proved to not increase the R^{*2} value enough to motivate the added complexity.

Using the test environment, searching for models as described above, resulted in a total of four demand & supply models; North-South 3 month (NS3), North-South 6 month (NS6), South-North 3 month (SN3) and South-North 6 month (SN6). The results of the regression are five indices for each model with different coefficients associated.

Table 17: Indices and coefficients for the four demand & supply models.

Model: North-South 3 months		**R^{*2} = 94 %**	
Variables	**Description**	**Coefficient**	**Impact**
Cocoa-ICCO Daily Price US$/MT	Cocoa Price	-0,0002	-39 %
CRB Spot Index Metals	Metal Price Index	0,0017	92 %
EURO AREA BOND YIELD CORPORATE	Corporate Bond Yield Index	-0,0621	-28 %
Rapeseed Oil-Crude FOB R'dam £/MT	Rapeseed Oil	0,0012	59 %
SWEDEN BOND YIELD CORPORATE	Corporate Bond Yield Index	0,0157	6 %
Intercept	Constant	0,1097	10 %
Model: South-North 3 months		R^{*2} = 87 %	
Variables	**Description**	**Coefficient**	**Impact**
Cocoa-ICCO Daily Price US$/MT	Cocoa Price	0,0002	94 %
CRB Spot Index Metals	Metal Price Index	0,0004	63 %
EURO AREA BOND YIELD CORPORATE	Corporate Bond Yield Index	-0,4119	-512 %
Rapeseed Oil-Crude FOB R'dam £/MT	Rapeseed Oil	0,0023	296 %
SWEDEN BOND YIELD CORPORATE	Corporate Bond Yield Index	0,0629	71 %
Intercept	Constant	0,3576	87 %
Model: North-South 6 months		R*2 = 92 %	
Variables	**Description**	**Coefficient**	**Impact**
Dow Jones UBS-Spot Commodity Index	Commodity Index	0,0048	122 %
EURO AREA BOND YIELD CORPORATE	Corporate Bond Yield Index	0,0302	13 %
S&P CHINA BMI	China Stock Index	0,0014	29 %
S&P GSCI Commodity Spot	Commodity Index	-0,0031	-124 %
STOXX EUROPE TM MINING E	Industry Stock Index	0,0012	99 %
Intercept	Constant	-0,4733	-39 %
Model: South-North 6 months		R^{*2} = 79 %	
Variables	**Description**	**Coefficient**	**Impact**
Dow Jones UBS-Spot Commodity Index	Commodity Index	0,0111	640 %
EURO AREA BOND YIELD CORPORATE	Corporate Bond Yield Index	-0,2630	-248 %
S&P CHINA BMI	China Stock Index	0,0043	197 %
S&P GSCI Commodity Spot	Commodity Index	-0,0036	-329 %
STOXX EUROPE TM MINING E	Industry Stock Index	-0,0004	-76 %
Intercept	Constant	-0,4480	-83 %

For the 3 month models the indices were a cocoa price index, a metal price index, two bond yield indices and a price index for rapeseed oil. This gave an R^{*2} of 94 % for the North-South model and 87% for the South-North model. For the 6 month models the indices were two commodity index, an index for the European mining industry, a composite index of Chinese stocks and a bond yield index. The combination resulting in an R^{*2} of 92 % for the North-South model and 79% for the South-North model (see Table 17 on the previous page).

6.4.3 Demand & supply model fit

A successful regression model must have a sufficient model fit. Model fit, in this context, is defined as a regression model's ability to recreate the underlying data, in this case the MA5 of the first 28 months. The model fit is thus the first test of the regression model's performance.

The adaptions of the four different models to the five month moving average demand & supply effect are shown in the below plots, where the 28 months of Ma5 data is represented by the blue bars, while the models' respective adaption is represented by the red line. To review these figures gives qualitative information about the models' fit, which in the next subchapter will be complemented by quantitative statistics.

The NS3 model shows an overall good fit to the MA5 data for the North-South route. The overall trend is well captured by the model and the movement of the model seems to be smooth and stable. This is illustrated in Figure 27.

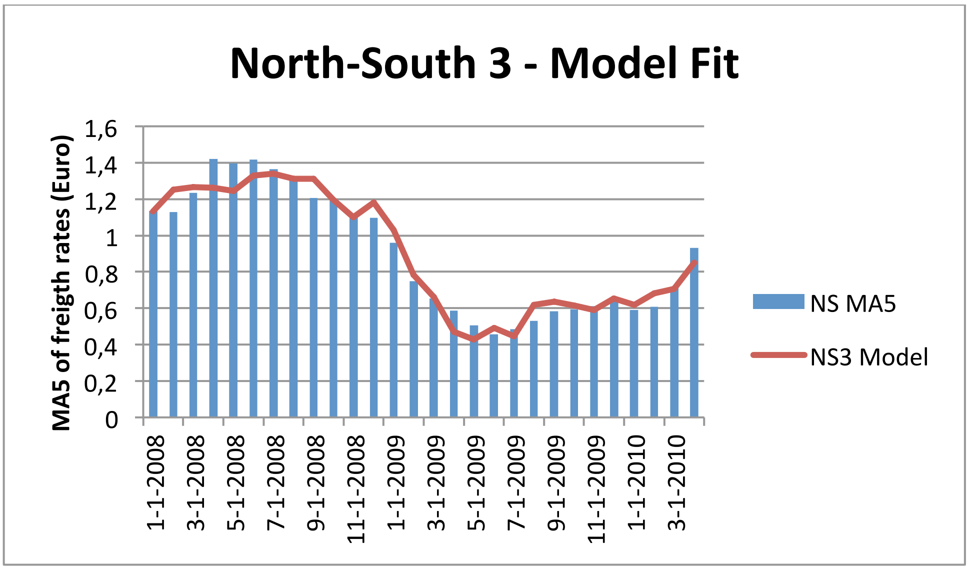


Figure 27: North-South 3 – Model's fit to the underlying data

The SN3 model (see Figure 28) is replicating the overall trend of the data. However, there are some oscillations between June 2008 and December 2008 indicating that the SN3 model is somewhat sensitive to the underlying indices' movements, and hence less stable than the previously presented NS3 model.

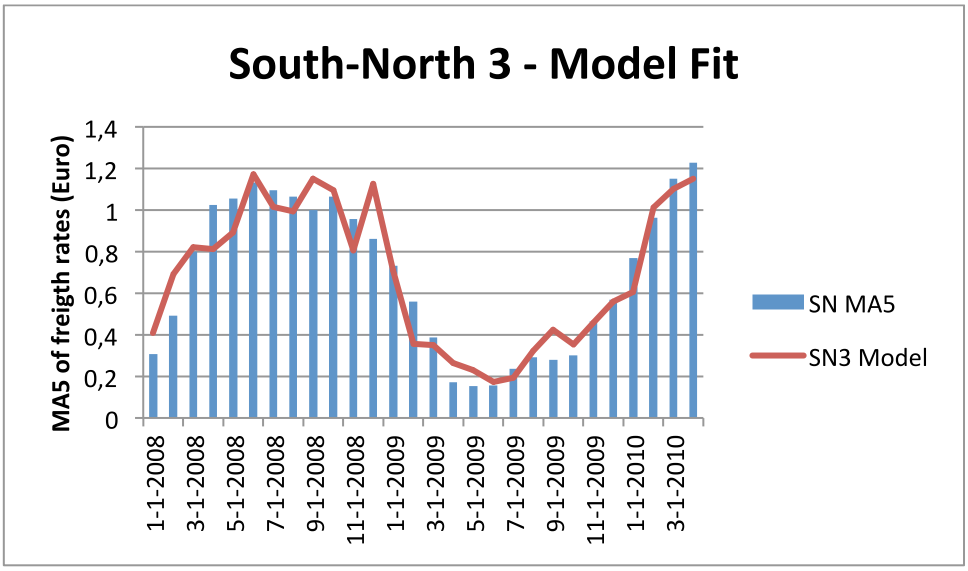


Figure 28: South-North 3 – Model's fit to the underlying data

The NS6 model shows (see Figure 29 below) on average a good ability to represent the overall trend. However, compared to the NS3 model, the accuracy of individual months is lower. This lower accuracy is though expected since the accuracy is theoretically expected to decrease as the NS6 model's values is calculated on 6 months old index values, compared to 3 months for the NS3 model.

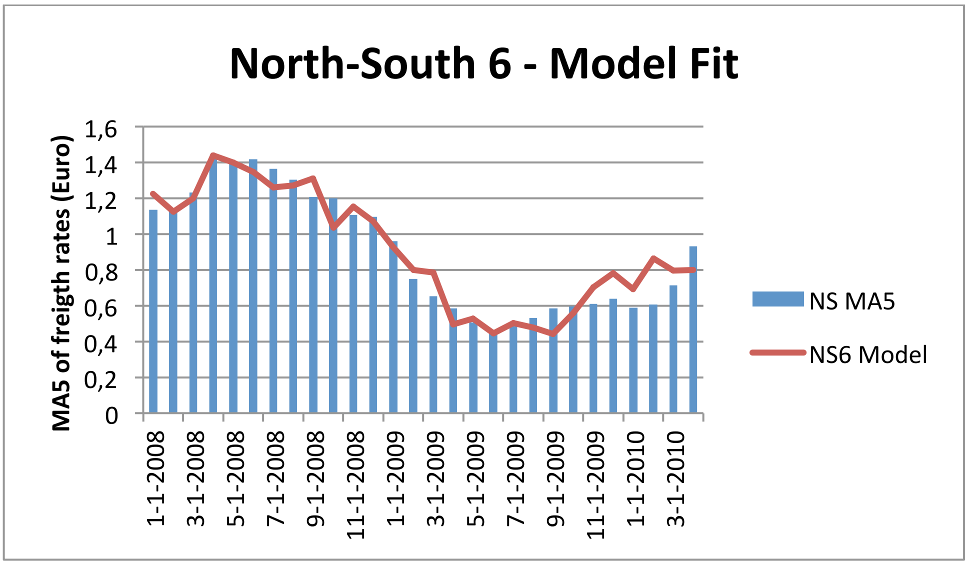


Figure 29: North-South 6 – Model's fit to the underlying data

Finally the SN6 model (see Figure 30) is showing the same result, compared to SN3, as the difference between NS6 and NS3. The SN6 captures the overall trend well, but the accuracy is less than for the SN3 model.

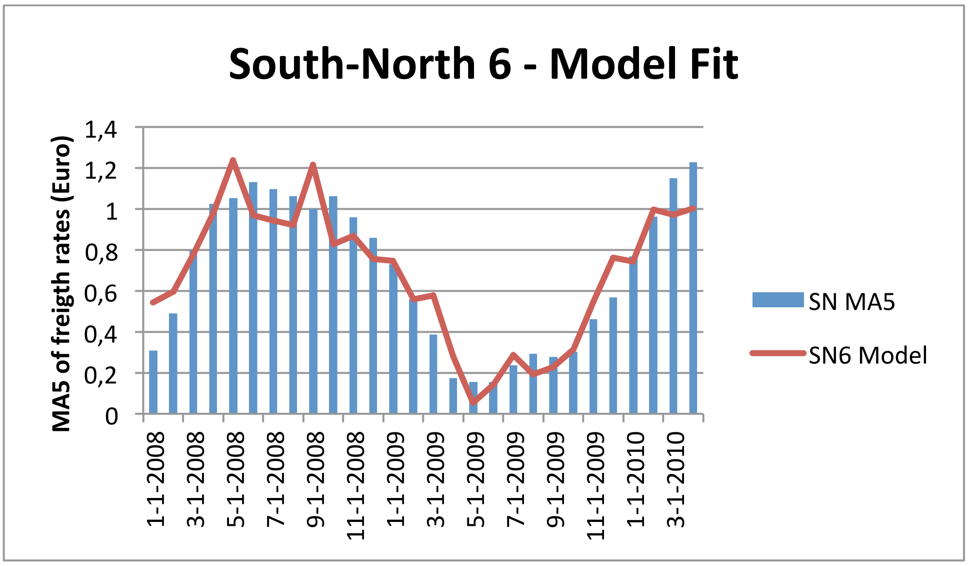


Figure 30: South-North 6 – Model's fit to the underlying data

In conclusion all the models have a good model fit, with the ability to recapture the overall trend of the underlying data. Since the final forecasting model's primary purpose is to forecast trends, the separate models' ability to capture the trend in the model data is a good indication. However, further validation was necessary before these models could be finally confirmed.

6.4.4 Validation of demand & supply model

One of the most important features of a model is that it is logic and in line with the theoretical findings. Since much effort was put into choosing the index with regard to this, the models logic and alignment with theory is good. The combinations of indices covers most factors found during interviews and literature studies of the master thesis. This is the most important validation of the model.

Apart from the qualitative validation, discussed above, a quantitative validation is necessary. To be able to validate the models quantitatively, one can investigate the adjusted multiple correlation coefficient, R^{*2} (see chapter 3.4.4), and the residuals of the models. The R^{*2} is a measure of how much of the underlying data's (MA5) variance that is contained in the model, while a residual analysis will give proof whether the underlying assumptions of the regression model is fulfilled.

The R^{*2} values of all models are on a generally high level, the models are able to replicate 79 – 94 % of the variance of the MA5 data. This gives evidence that the overall fit of the models is on an acceptable level. However, as earlier seen in the plots, the long-term models (NS6 and SN6) has a lower R^{*2} value than the short-term models (NS3 and SN3). Again, this is expected because of the increased difficulty to represent the data (MA5) at time *t* with a model based on index values from time *t-6* (see Table 18).

Table 18: Model fit and residual test statistics for the four models.

Modell	North-South 3	South-North 3	North-South 6	South-North 6
Nbr Variables	5	5	5	5
R^{*2}	94 %	87 %	92 %	79 %
Residual Test				
Average	10^{-7}	10^{-7}	-0,008	0,006
Jacque-Berra	1,34	0,16	0,58	1,31
Durbin Watson	1,21	1,89	1,53	1,73

Residual analysis

As mentioned in the theory chapter (3.4) a regression model's significance is dependent on three assumptions regarding the residuals: independence of residuals, homoscedasticity of residuals and approximately normal distributed residuals. If these assumptions do not hold, the regression model might be unstable and statistical tests will not be valid. To be able to verify and validate the four regression models presented above, a residual analysis is presented in the following paragraphs.

Independence of residuals

The independence of the residuals can be confirmed by looking firstly, at the autocorrelation functions of the residuals and secondly, at the Durbin-Watson statistic. According to the autocorrelation functions (see Figure 31), the autocorrelation for all lags (except zero) is within the 95 % confidence interval, indicating that there is no significant autocorrelation for any of the models' residuals.

In Figure 31 (see next page) the autocorrelation function is shown for the four models. All blue bars indicate the correlation between the residuals (y-axis) at a certain time lag in months (x-axis) for each of the models. The first bar in all plots hence represents the correlation of the residuals to themselves without any time lag, which is always equal to one. In the plots there is a 95 % confidence interval, indicating whether the autocorrelation is significantly different from zero or not, marked as a red and a green dotted line. It is preferred that the correlation is zero at all time lags but zero, but as long the correlation (the blue bars) is within the confidence interval there is no clear evidence for autocorrelation. In the figure, none of the blue bars are outside the confidence interval, indicating that the autocorrelation, for all models, is not significantly different from zero at the 95 % confidence level.

The Durbin-Watson (DW) statistic describes whether the residuals, with one month lag, are autocorrelated or not. The four regression models were created on 28 observations and with 5 variables which gives that the 95 % confidence intervals are 0 to 1.03 for a significantly positive autocorrelation, 1.03 to 1.85 for unknown existence of positive autocorrelation and 1.85 to 2.15 for no autocorrelation at time lag one.[96] The North-South 3 month (NS3) model have a DW value of 1.21 and the North-South 6 month (NS6) model 1.53 which is neither indicating existing or non-existing autocorrelation at lag one. For the South-North 3 month (SN3) model the DW value

---

[96] (Makridakis, Wheelwright, & Hyndman, 1998)

of 1.89 give a proof of no existing autocorrelation at lag one. For the South-North 6 month (SN6) model the result is unknown since the DW value is 1.73. Hence, the DW analysis result, is that three of the models cannot for sure be verified if they have autocorrelation at lag one or not, while the South-North 3 month model have a significant result of no autocorrelation.

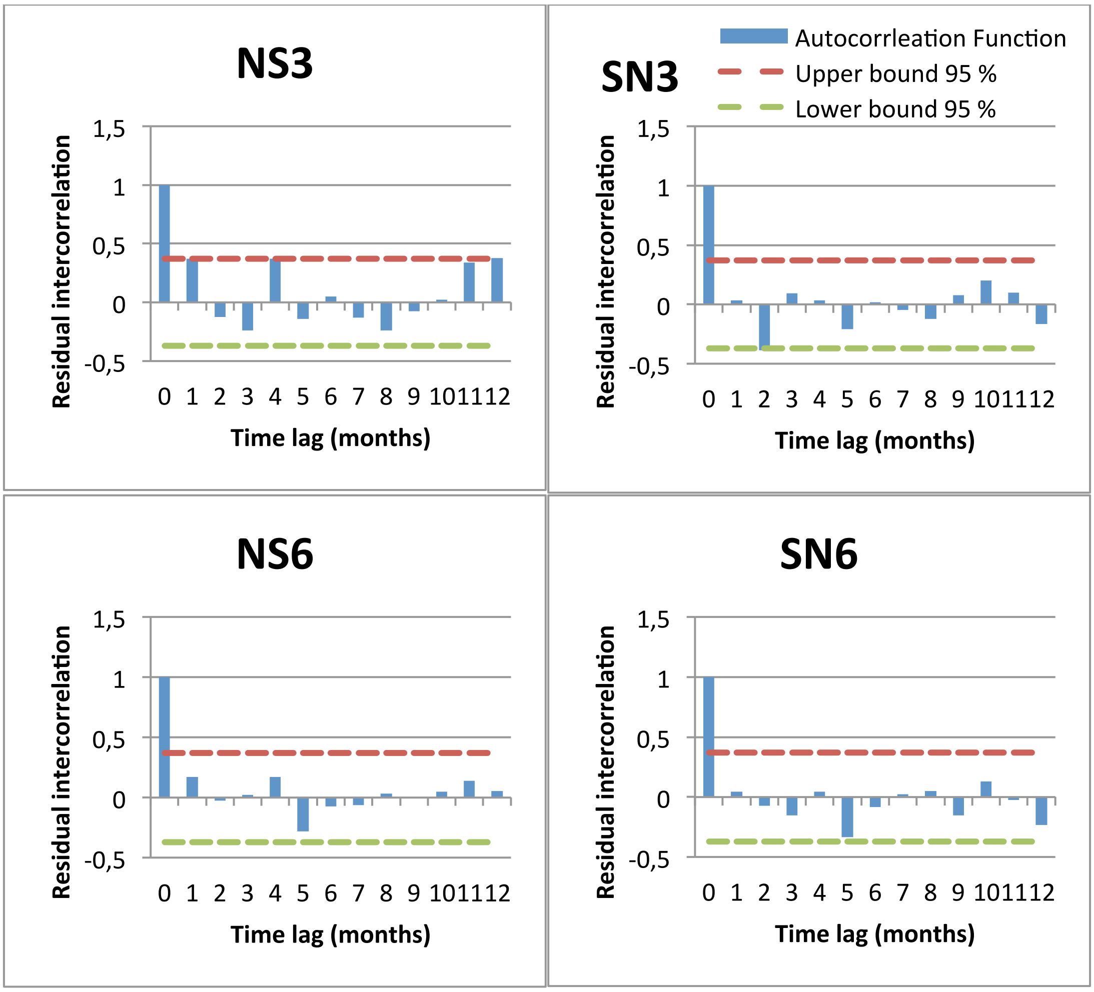


Figure 31: Autocorrelation function for the four models.

Combining the results from the autocorrelation function plots and the DW statistic one can verify that there are no strong evidences towards autocorrelation. Hence the assumption of independent residuals holds.

Homoscedasticity of residuals

That the second assumption about homoscedasticity holds, is verified by the below plots showing the residuals plotted against the demand and supply effect (MA5) for respectively North-South (NS) and South-North (SN).

In Figure 32 (see next page) there is one homoscedasticity plot for each of the four models. The plots show the relation between the residuals and the MA5 of the respective route (either North-South or South-North). None of the models have a clear pattern or any other obvious relation in the plots. Hence, the residuals are not dependent on the model, or vice versa. This is indicating that the residuals have a finite variance, hence the second assumption about homoscedastic (non-heteroscedastic) residuals holds.

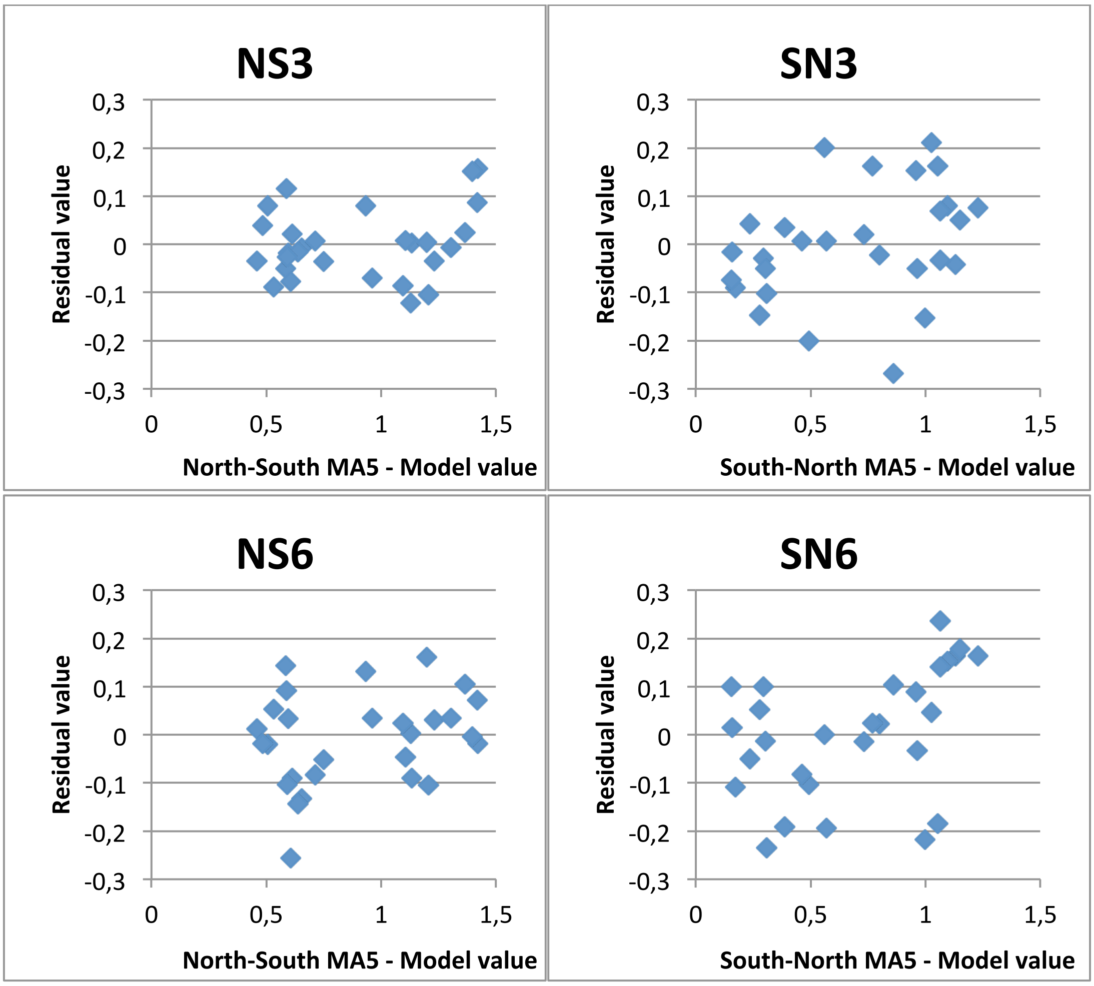


Figure 32: Test plot for homoscedasticity

Normal distributed residuals

Lastly, the assumption of approximately normal distributed residuals needs to be verified, i.e. the residuals should have a normal distribution with expected value zero. First, all models have an average value very close to zero which indicates that the expected value very well could be zero. Jarque-Bera (JB) statistic tests whether the zero hypothesis, that the residuals are normally distributed, can be rejected or not. In the case of 28 observations the 95 % confidence interval threshold for rejection is at 4.4, i.e. if the JB statistic is larger than 4.4 the residuals are significantly non-normal.[97] The four models of this thesis has JB statistics ranging from 0.016 until 1.34, i.e. none of the models' JB statistics is larger than 4.4 (all JB tests passed). Hence, the residuals of all four models could very well be normally distributed.

To further investigate the normality, the residuals were plotted in histograms and compared to the theoretical normal distribution (see Figure 33). The blue normal curves in the plots in Figure 33 are based on the theoretical normal distribution of the residuals, where the width of the

[97] Acquired from Matlab ©, based on theories from (Mooney, 1997)

curve is determined by the residual variance. As can be seen in the plots the actual residuals of the NS3 and NS6 models have a good fit to the theoretical normal distribution, with a bell shaped look of the distribution of the residuals. SN3 and SN6 both have a less convincing look, indicating that the residuals might not be perfectly normally distributed.

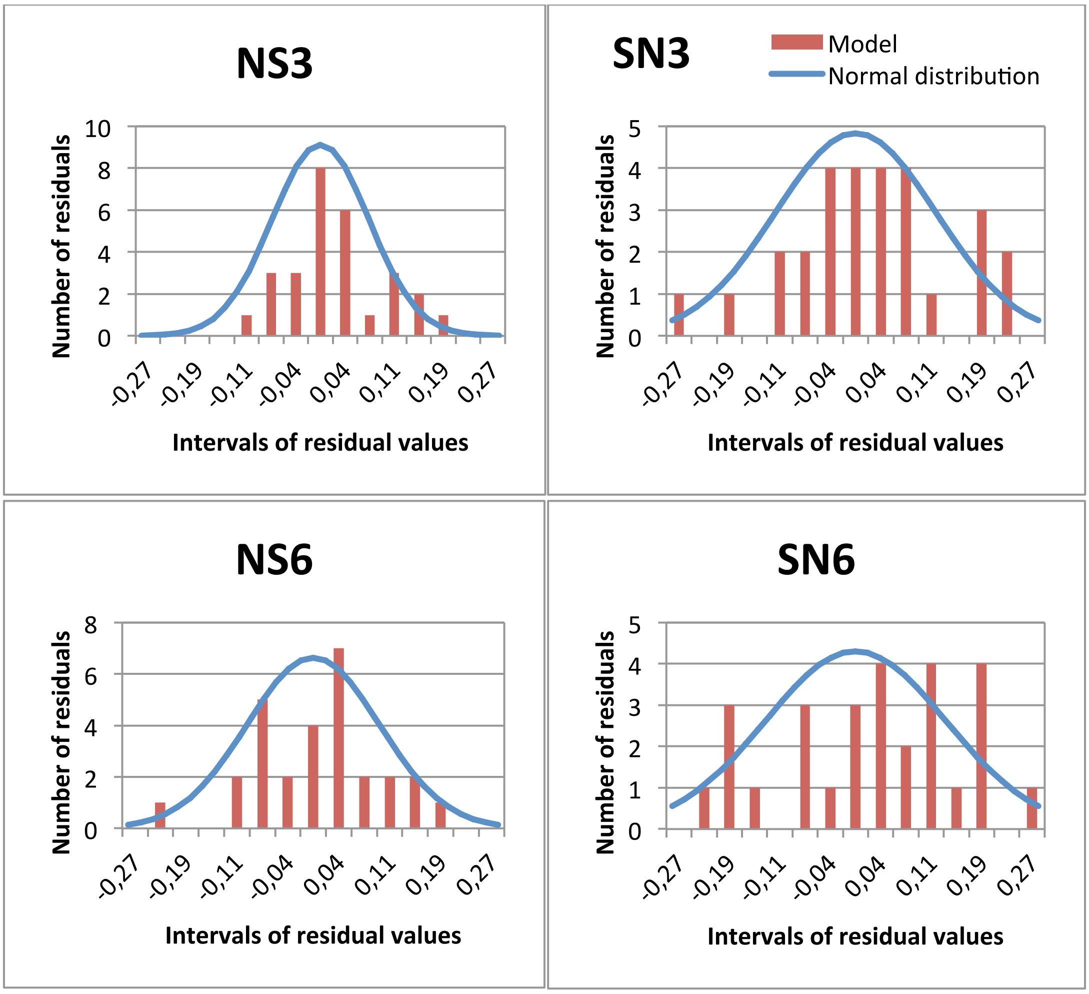


Figure 33: Histograms of the residuals and normal distribution for the four models.

Combining the results of both the Jarque-Bera and the residual histograms the conclusion becomes that the residuals are approximately normally distributed. This is enough for the assumption to hold, and even if this should prove to be somewhat incorrect, neither the model's forecasting accuracy nor the model's coefficients will be affected.[98] The normality assumption is thus the least serious assumption.

In the continuation of the thesis the residuals will be assumed to be approximate normal distributed. And with this last confirmation, there is proof that the assumptions underlying the regression models all have been fulfilled, the models are therefore validated.

[98] (Makridakis, Wheelwright, & Hyndman, 1998)

6.5 Forecasting ability of demand & supply model

In this section the forecasting ability of the model is tested. Since the models are built on the first 28 months, the prediction can be tested on the following 7 months of whom data exist. If the models are able to forecast these 7 months, there is a good indication that the models are able to accurately replicate the market movements also in the future.

6.5.1 Validation of forecasting ability

For the two models with three month time lag, NS3 and SN3, the maximal forecasting horizon is three months. While the six month models, NS6 and SN6, are able to predict the market with a six month forecasting horizon.

Since the model was built on the first 28 of total 35 observed months of freight rates it was possible to validate the forecasting ability by comparing the values of the model with the last seven months; from May to November 2010. Three different ways of validating the model were used. For every one of the sub models, NS3, SN3, NS6 and SN6, the Mean Absolute Percentage Error (MAPE) and Mean Square Errors (MSE) for the last 7 months were calculated. The models were also plotted against the observations for all of the 35 months.

First, both the MAPE and MSE are sufficiently low to say that the prediction ability is good, for all models. Second, the width of a 95 % confidence interval for the forecasts was also calculated, based on the MSE for all observations and the assumption that the residuals have an approximate normal distribution (see residual analysis on page 63). The interval's width, which is relatively small (the largest being 0,493 for the SN6 model), gives an indication of the accuracy of the forecast of the specific models. The intervals confirm the previous observation that the 6 month forecasts are less accurate than the 3 month forecasts for each specific route. For example NS3 have a less wide interval than NS6 (see Table 19).

Table 19: Prediction Ability of the models

Modell	North-South 3	South-North 3	North-South 6	South-North 6
<u>Prediction Test</u>				
MAPE forecasts	9,8 %	4,2 %	7,3 %	5,5 %
MSE forecasts	0,016	0,004	0,011	0,009
Width of 95 % confidence interval	0,336	0,403	0,378	0,493

In the plots the forecasting for each model was represented by a green line, while the actual market situation of those seven months were represented by purple bars. The NS3 model showed a good ability to forecast the growing trend of market. However there might be some indications that the forecast is slightly below the actual market situation (see Figure 34).

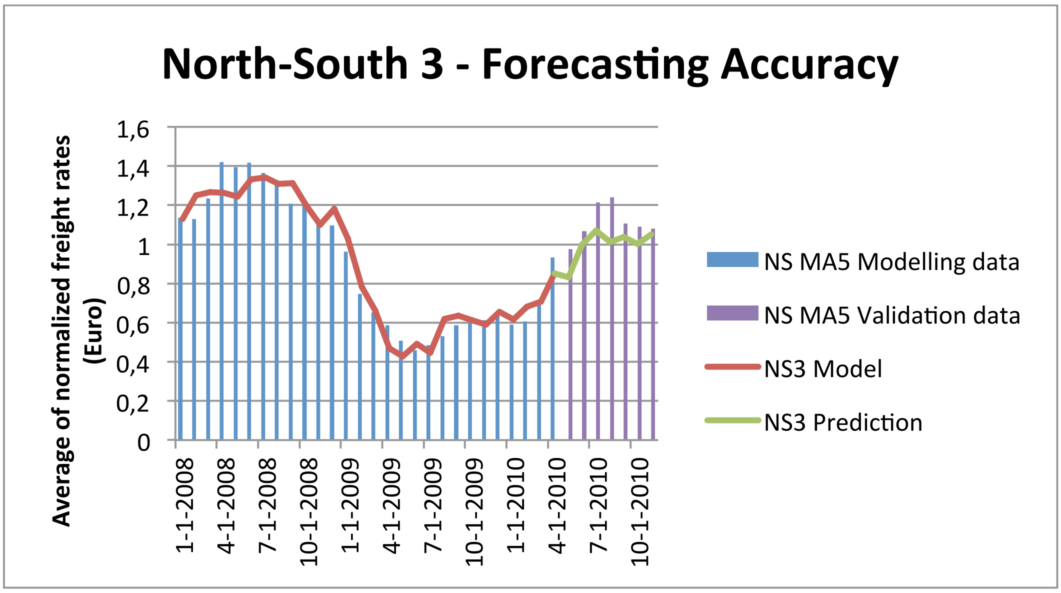


Figure 34: Forecasting accuracy of the NS3 model.

The SN3 model accurately captures the growing market and also shows a good ability to correctly forecast the market level in specific months, in the majority of the seven validation months (see Figure 35).

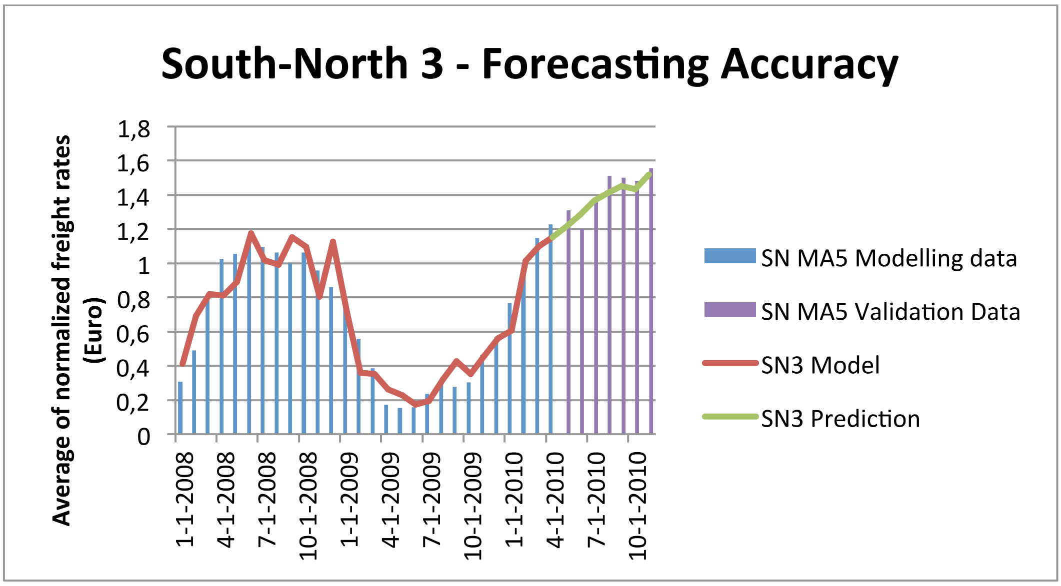


Figure 35: Forecasting accuracy of the SN3 model.

The NS6 model is also able to forecast the growing market. Surprisingly, it seems to be more accurate than the NS3 (longer horizon should give less accuracy) (see Figure 36).

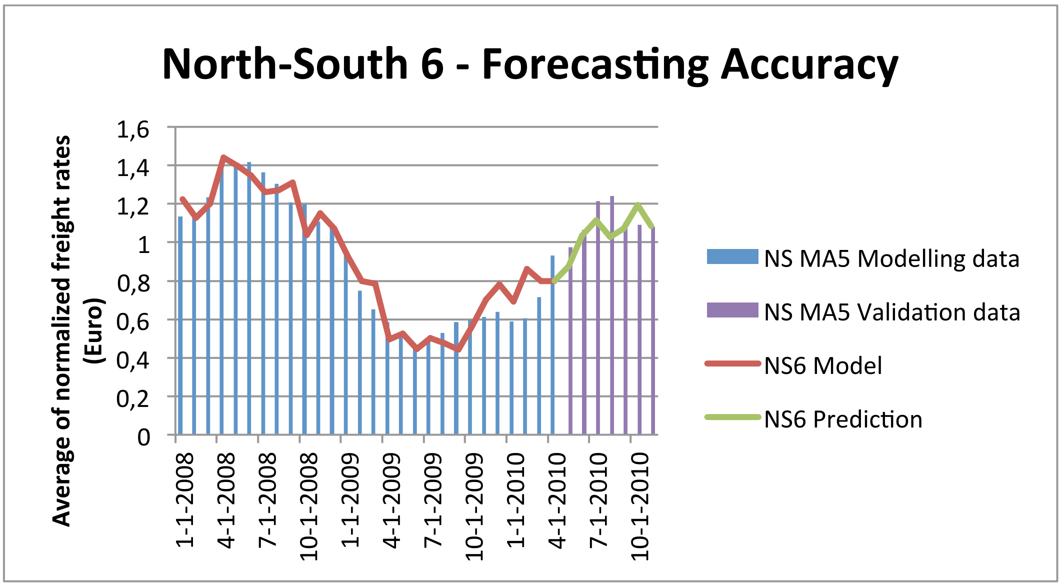


Figure 36: Forecasting accuracy of the NS6 model.

The SN6 model has very good forecasting results, and is, similar to SN3, able to not only forecast the overall growing trend, but also fairly accurately the specific monthly situation (see Figure 37).

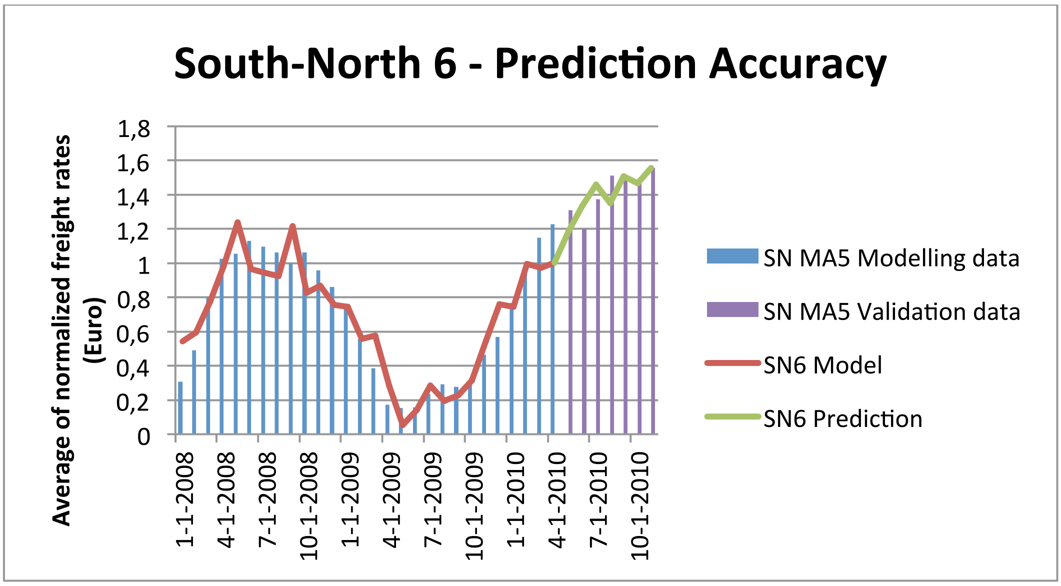
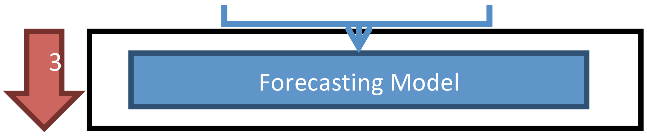


Figure 37: Forecasting accuracy of the SN6 model.

With the results from the plots in Figure 34 to Figure 37 and Table 19 the conclusion from the validation is that the model has the ability to do accurate forecasts. However, the fact that only seven observations could be used for validation should be kept in mind.

7 Step 3 – Usability, design and evaluation of the forecasting model



This chapter will discuss how the findings will be used, the design of the tool that was delivered to Lantmännen and an valuation of that tool. This chapter will also evaluate the forecasting model from a more qualitative perspective.

7.1 Using the forecasting model

The forecasting model is supposed to provide Lantmännen with information, which will help them make better decisions when procuring sea freight services. The model will provide Lantmännen with 3 and 6 month forecasts into the future, helping them to make decisions about whether to fix freight services now or wait for market improvement, or conversely.

Another positive effect with implementing the model is the possibility of an internal high level discussion about shipping procurement. The model can act as a mediate tool that will facilitate communication and knowledge sharing between different internal procurement organizations. As the model is updated, the new forecasts could be discussed and an internal agreement can be made about the short and long term strategy. This is suitable, for example, for making decisions regarding incoterms when purchasing commodities or determining whether to secure sea freight far in advance or wait for a decline in spot prices. The model gives Lantmännen concrete quantitative information that together with qualitative knowledge and experience will increase the opportunity of making successful procurement strategy decisions.

Finally the model will also provide further understanding regarding what indicators and indices that have an impact on future freight rates. The indices suggested by this model can form the basis for discussion and facilitate a deeper understanding on what affects the market. The model will also provide Lantmännen with complementary market information, decreasing their dependence on third party organizations with separate agendas, primarily shipbrokers.

Since the model is built on monthly data, it is natural to update the model on a monthly basis and share it through internal meetings, e.g. the monthly meeting of the ship freight purchasing organization.

7.2 Designing the forecasting model

The design of the model is determined by the intentions to create a tool that should be easy to understand and communicate. These intentions implicate both a low level of detail, high level of relevance and a suitable packaging of the information.

To keep a low but relevant level of information the tool will display only the most relevant information. The four forecasts are supplied on example routes, one common route for North-South and one for South-North. The forecasts is given both as an percentage increase for 3 and 6 months compared to today, and as an absolute range of the freight rate. The range given is based on the 95 % confidence interval (presented in chapter 6.5.1). The underlying indices' movements since 3 respectively 6 months are also presented in percent. To improve the interpretation, arrows are supplied for each percentage, with an angle proportional to the increase/decrease. The arrows are also colored either red or green dependent on an increased or decreased price (since a decrease is positive from Lantmännen's point of view it is colored green). Finally there are plus and minus signs indicating whether the coefficient for each specific index is positive or negative, the colors of the index arrows are inverted if the sign is negative, e.g. if an index have a negative coefficient and was increasing it will have a decreasing effect of on the price and hence a green color (see Figure 38).

The tool also calculates forecasts of freight rates for specific routes in absolute terms (i.e. euro/ton). There are three different example routes presented by the tool, one from each section. For the Spannmål section the route is between Norrköping and Sevilla, for Foder the route is between Hamburg and Lidköping and for Cerealia DK the route between Uddevalla and Vejle. All these routes were chosen because they are the most frequently used routes for each respective section, based on the database used for this master thesis. The freight rates for these routes are given in an interval form, where the midpoint of the interval represents the forecast (3 or 6 month) and the width of the interval a 95 % confidence interval based on the variance of the residuals for the respective model (presented in the last row of Table 19).

The tool is constructed in Microsoft Excel© and fits neatly into one sheet. This sheet could then easily be copied into Microsoft Power Point© for easy distribution within the organization. Figure 38 represent a part of the tool, the SN3 model. The layout is the same for the other models and they are fitted next to each other into one single sheet.

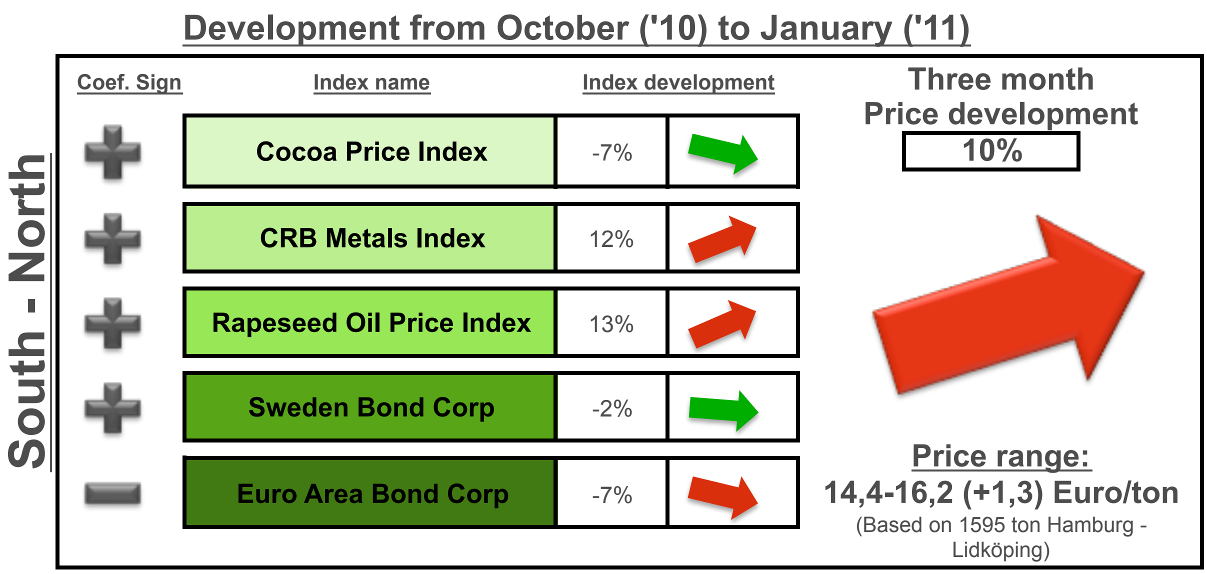


Figure 38: Part of the Freight Rate Predictor that shows the SN3 models prediction of January 2011.

Every month the internal owner of the tool will need to manually update the 13 indices needed to make the forecasts, update the model and distribute the new forecasts.

7.3 Validation of the forecasting model

The accuracy of the forecasting model to illustrate market trends has already been validated in chapter 6.5.1. The results indicated that the model can do accurate forecasts of the overall market trend.

Even though the most important part of the model, the capability to forecast the overall trends, was already validated, there was still a need to validate whether the model could give accurate forecasts for the three example routes, Hamburg-Linköping, Uddevalla-Vejle and Norrköping-Sevilla, used by the model. To verify this accuracy, the model was set to forecast rates for dates were actual historical freight rates existed, on all of these three routes. The actual rates were then compared to the forecasted rates.

For the route Hamburg-Linköping the accuracy is overall very high. For example the model's successfully identified the downward trend during early 2009 and the growing trend during 2010 (see Figure 39). For the route between Uddevalla and Vejle the forecasting model again shows convincing results in forecasting the actual freight rates. The model is especially successful in forecasting the downturn in the beginning of 2009. However, the model fails to forecast the high rates in the end of the year 2009 (see Figure 40). The few existing observations for the route route between Norrköping and Sevilla lead to an inconclusive analysis of the overall forecasting accuracy of the model. The forecasting model seems to be less accurate, and as can be seen in the above picture the actual rates were less volatile than suggested by the model. The model overestimated the price in the beginning of 2009, but the model succeeds in forecasting the growing trend in the later part of 2009, even though the last observation is even higher than the forecast (see Figure 41).

In the following graphs (Figure 39 to Figure 41) the results used for validation of the forecasting accuracy of the three example routes are presented. In the graphs the historical full ship freight rates, i.e. the freight rate for a full ship, are given by blue bars while the two forecasts are given by a red dotted line (3 month forecast) and a yellow dotted line (6 month forecast).

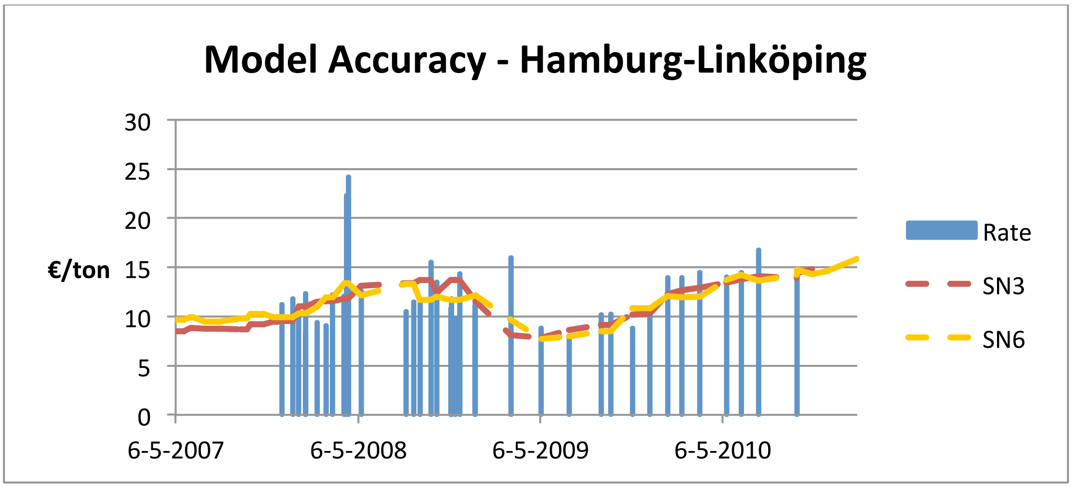


Figure 39: Model Accuracy - Hamburg-Linköping

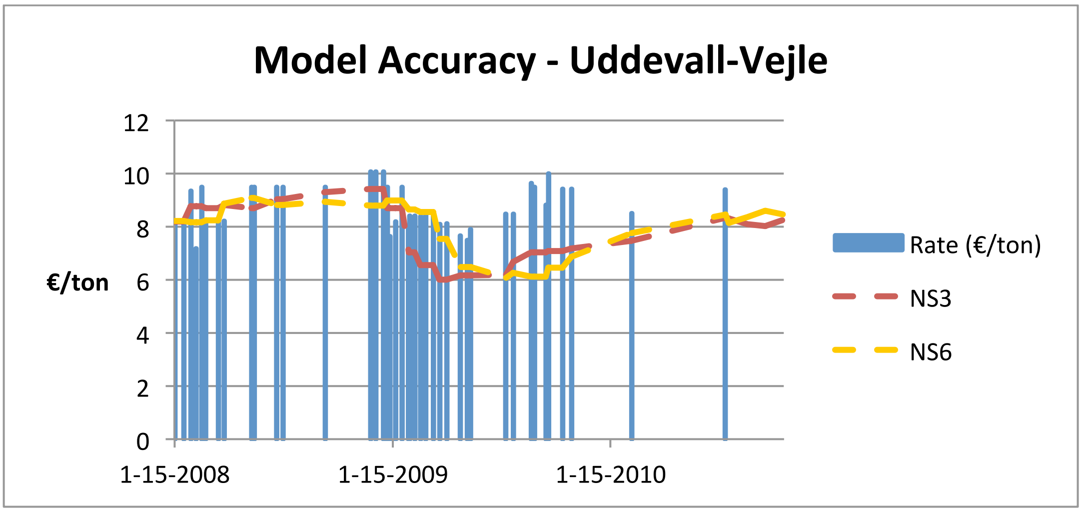


Figure 40: Model Accuracy - Uddevalla-Vejle

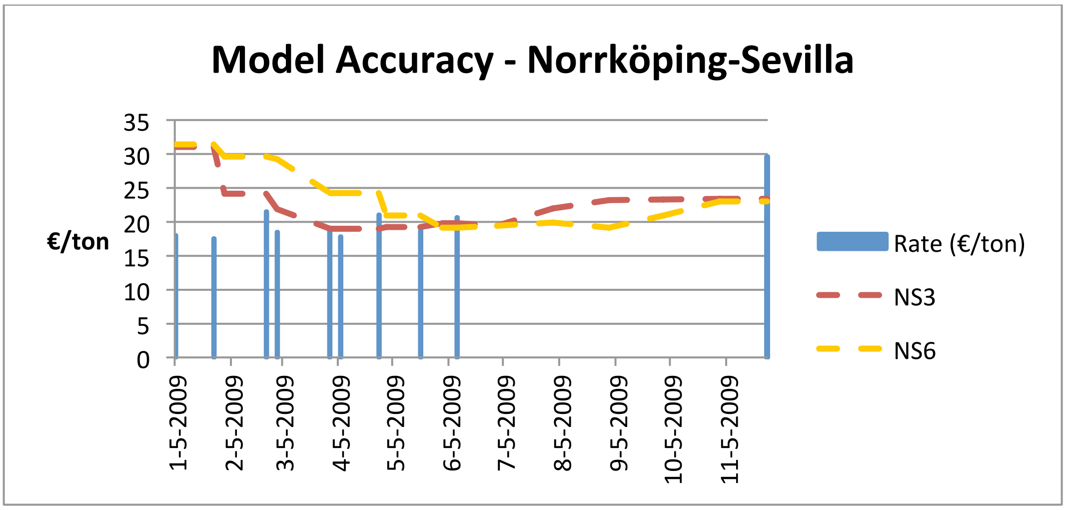


Figure 41: Model Accuracy - Norrköping-Sevilla

The forecasting model's ability to predict the three example routes is acceptable, with very good results for two of the three routes. However, the lower accuracy for Norrköping-Sevilla that appears to exist should be kept in mind when using that specific route example. From a general perspective it is also important to remember that the primary aim of the model is not to calculate specific freight rates, but to forecast the overall trends of the market. This ability to forecast overall trends with good accuracy has been validated in chapter 6.5.1.

7.4 Evaluation of the forecasting model

The forecasting model that is the end result of this master thesis is constructed and tested on the market situation of January 2008 until November 2010. The fact that the model development and the verification of the model are based on a certain period, raises concerns about this period's ability to represent the market conditions also in the future accurately. This is a two folded problem that only can be dealt with by first looking at the specific period's nature and whether any abnormal events occurred during this period. Second, it has to be evaluated what the implications will be for the model with changed market conditions in the future. The limitations that the model has are presented briefly in Table 20 and discussed in more detail below.

Table 20: Limitations of the model

Fact	Limitation
Built on a period which included financial crisis	Model accuracy might decrease in future
Market conditions will change (long-term)	Long-term decrease of accuracy
Market relations will change (long-term)	Chosen indices might lose some relevance
Non-economical factors not modeled	Changes in non-economical factors might change market in a way the model cannot recreate
Effect of different fixing date for freights not modeled	Less accurate for unusually long- or short-term freight fixings.

Again, first the period used for development and validation need to be examined to verify if it is likely that it is a period that could represent also the future. The period used for development and validation basically covers the three years of 2008, 2009 and 2010. This is a relatively long period of time, which suggests that some stability is built into the model. The model is also tested and validated using the most recent data available, i.e. data for the second half of 2010 up until December, making sure that the model is able to forecast the most recent events accurately. However, the period contains the most severe financial crisis since the depression in 1930, a crisis that had implications on the whole world's economy and also on most industrial markets. The financial crisis is definitely an abnormal event, from a long-term perspective, that is included in the period. This might have the implication that the model will not accurately represent and forecast periods in the future, when the wake of the financial crisis has disappeared. The period is however also containing roughly 5-8 months in the beginning of 2008: before the financial crisis really occurred. It also contains, basically, the whole of 2009 and 2010: when the impact of the financial crisis gradually have been decreasing. This leads to the conclusive evaluation that the period used might generate a model with less accuracy in the future, but the fact that three whole years is contained in the period, both before and after the crisis, hopefully decreases this effect.

Secondly, it is important to understand what implications a change in future market conditions will have on the model's accuracy and validity. From a general perspective the future always brings some changed settings and conditions, relative to the past. This will definitely be the fact also for the specific part of the shipping industry studied in this master thesis, although it is impossible to accurately predict which changes that will occur and how fast. The authors of this master thesis want to stress the fact that changes will occur and that these will have a long-term effect of decreasing the forecasting model's accuracy.

The market relations that was identified, which formed the foundation for the development of the model will change over time. For example the relations of the indices, chosen for the regression models, might lose some of its relevance. Also as discussed in the PESTEL analysis (section 6.1.1), non-economical factors are not directly included in the model and hence a change in those might have larger effects on the freight rates than what the model can recreate.

For example a certain political or legal change might completely change the conditions for the shipping industry in the region. However, it is important to realize that the model structure chosen, i.e. a regression model, is a very robust structure since it depends on external indices instead of internal data.

A limitation of the model is that it does not wholly address the difference in freight rates that might occur due to choices of fixing freights (signing contracts), in long or short term before the actual shipping date. The forecasting model is based on Lantmännen's historical freight rates, where no information was available regarding in what advance the freight rates were agreed. This implies that the forecasting model's forecasts are based on an unknown average time of freight fixing. This means that the model will probably not accurately forecast extremely long-term and short-term freight fixings. The forecasting model's forecasts are valid for pointing out the direction where the market is moving, but not directly giving any information of when exactly the right time is for fixing the freight rate and sign the contract. However, the forecasting model indicates in what direction the market is heading and hence giving a suggestion whether it is rational to wait for a market price decrease or use long-term contracts when the price is expected to increase.

8 Conclusion

In this chapter overall conclusions of the master thesis is presented, together with reflections on research quality. The chapter also contains suggestions to Lantmännen on how to successfully continue their work with the forecasting model. Finally, suggestions on further research within this field are discussed.

8.1 General conclusions

This master thesis has been carried out with the main purpose to provide Lantmännen with information that should enable them to make better decisions when purchasing sea freight services. This was done particularly by creating a forecasting model for their freight rates.

The secondary purpose of the master thesis was to develop a process for developing price indices and forecasting models. This was done by the development of a method that focused on an initial qualitative data collection followed by a quantitative statistical development process.

Both the purposes were achieved successfully. The forecasting model was developed and tested with good results, indicating that the first purpose is achieved. If Lantmännen uses the model as intended they will acquire new knowledge that will help them make better decisions when purchasing sea freight services. That the second purpose is fulfilled was apparent since the method that was used to structurally develop this model was successful. Even though the process developed in this thesis showed good results, it might not be possible to apply to all situations. This since the structure for the model, were freight rates are divided upon costs and a demand and supply effect, was based upon findings about the nature of the dry bulk sea freight market. The process should however be valid for developing price indices for those markets where there generally is a low differentiation in offered products or services.

In conclusion, this master thesis has been able to deliver what was expected and fulfill the purposes that were initially set up. Lantmännen now has a tool that gives them more information about the shipping market and hence the possibility to make better purchasing decisions.

8.2 Reflections on research quality – validity and reliability

In this master thesis the internal validity was kept high through the broad approach used in the qualitative part of the study. This approach results in a broad understanding of the causality of the specific problem and the industry in general. All assumptions and theories used in the quantitative part of model development were based on the findings from literature and interviews. This implies that the internal validity was on a high level.

The external validity in the study was harder to verify since the study was performed only on Lantmännen. However similar results could probably be found also for other companies with similar transportation needs. However, the results were based on a very specific part of the shipping industry, which makes generalizations on other parts of the shipping industry hard. However the actual process of developing a forecasting model is definitely applicable to other industries and other transportation problems, although the end results would be different.

The reliability of the results was on a high level because of the research method's abductive approach, with an initial qualitative step that was later backed up by a quantitative study. This approach serves to minimize the chance of system and measurement errors, because all quality results were tested in a quantitative environment. However, since the problem is very complex with a large number of factors taking part there might be minor differences if the research was repeated. For example it is quite unlikely that a repetition of this thesis would end up in the exact same combination of indices for the regression models.

To verify that the actual models created held a high quality, a number of different statistical tools were used both during the creation of the model and to evaluate the finished model. Regression analysis was used toghether with logical test to decide, which explanatory variables that were significantly affecting the forecast variable. To compare different model setups tools as R^{*2} and residual analysis was used to evaluate, which models that had a good fit to the underlying data. The models overall forecasting ability, i.e. the ability to forecast trends, was tested by using MSE and MAPE measurements. The models ability to forecast specific freight rates on a certain number of example routes was also tested by looking at the models forecast on historical periods.

In conclusion the research quality is on a good level with both a high validity and reliability. This is due to the fact that the research's method was very systematical and containing several steps of validation along the process of creating the final forecasting model.

8.3 Suggestions to Lantmännen

The suggestions given to Lantmännen in this section are of two separate natures. First, there are suggestions regarding what can be done to ease and increase the probability for success for analyses like the one performed in this master thesis. Second, there are suggestions to Lantmännen on how to use the model created in this master thesis.

There is a clear need for Lantmännen to create a single database containing all freight information for the different divisions. Such a database could for example be realized by the usage of a common Business Intelligence (BI) system. A BI system with this information would allow detailed analyses like the one performed in this master thesis to be performed without a long period being spent on the collection and transformation of data.

If more and better data was available already when this master thesis was performed there would have been an opportunity to add autoregressive functionality to the models. An autoregressive model can also depend directly on historical freight rates compared to the models in this master thesis which only depends on external indices. This would add another dimension of stability to the model and possibly increase the probability of successful forecasts.

To verify a long-term success for the forecasting model, it needs to be continuously evaluated. In frequent intervals the forecast made by the model should be evaluated against real observations and any deviations should be discussed to verify if they can be explained by factors not covered by the model or if the model itself needs to be adjusted.

Another more practical suggestion is to make sure that the indices required to update the model are delivered frequently. If the model is not updated with new indices frequently the organization's usage of the model will not be effective. Neither will the continuous evaluation of the model be possible to carry out.

8.4 Suggestions on further research

There are some factors that have a large impact on the freight rates that were not included in the model developed in this master thesis. These effects are mainly the positions of the ships at any given time and the effect of weather. The positioning of ships is extremely important, especially for short term decisions, in deciding the supply and hence competitive situation for a specific route for a given time. E.g. if there is a quite urgent need of a transport from a northern Swedish port to Spain, the bargaining position of the transportation purchaser will depend on the number of boats in the northern Swedish area. The information about ships' current positions and destinations is freely available online, but to incorporate the information into a forecasting model would still be a large project. It could also be possible to look deeper into the positioning of ships. Since it is extremely important for the shipowners to be well positioned at all times they use route planning, which might be possible to predict.

The weather situation is also affecting the freight rates, e.g. if there is a cold winter with thick ice on the routes there are regulations on what ships that are allowed to set sail. And as the ice gets thicker even less ships are allowed, which of course decreases the supply and hence increases the freight rate. A less extreme effect of the weather is the effect rain has on loading and unloading of cargo. Most ships cannot load nor unload grain or feedstuff cargo when it is raining because of the risk of damp damage. A model that includes the effects of weather would create a more accurate description of the market situation. Again however, to successfully include weather effects would demand a large project and a more complex model.

An important part of future research is to include more observations of freight rates, preferably from a number of different companies. The increased transparency and generality would create a chance to conclude more accurately how the market is functioning and to model a more general market situation.

Finally, as mentioned in the end of chapter 7.4 the effect of fixing freights in a long/short term in advance of the actual transportation taking place, could also be an interesting subject for future research.

Bibliography

Wallén, G. (1996). *Vetenskapsteori och forskningsmetodik* (Vol. 2). Studentlitteratur.

van Weele, A. (2005). *Purchasing and Supply Chain Management: Analysis, Planning and Practice* (4th Edition ed.). Londo: Cengage.

Alizadeh, A. H., & Nomikos, N. K. (2009). *Shipping Derivatives and Risk Management.* Hampshire: Palgrave Macmillan.

Arnold, R. A. (2008). *Macroeconomics* (9th Edition ed.). Mason, OH, USA: South-Western Cengage Learning.

Baltic Exchange Information Services Ltd. (n.d.). Retrieved September 3, 2010, from The Baltic Exhange: http://www.balticexchange.com/default.asp?action=article&ID=3034

Chopra, S., & Meindl, P. (2004). *Supply Chain Management: Strategy, Planning and Operations* (Second Edition ed.). New Jersey: Pearson Education Inc.

Firth, M. (1977). *Forecasting Methods in Business and Management.* London: Edward Arnlod Ltd.

Gibson, B. J., Mentzer, J. T., & Cook, R. L. (2005). Supply chain management: the pursuit of a consensus definition. *Journal of Business Logisitics , 26* (2), 17-23.

Goodwin, N., Nelson, J. A., Ackerman, F., & Weisskopf, T. (2009). *Microeconomics in context* (2nd Edition ed.). New York: M.E. Sharpe, Inc.

Gorton, L., Hillenius, P., Ihre, R., & Sandevärn, A. (2009). *Shipbrokering and chartering practice* (Seventh Edition ed.). London: Informa.

ITF. (2008, January 1). *Itf sea farers.* Retrieved December 17, 2010, from http://www.itfseafarers.org/files/seealsodocs/9354/ITF%20Standard%202008.pdf

Hunger, D. J., & Wheelen, T. L. (2009). *Essentials of Strategic Management* (Fourth Edition ed.). New Jersey: Person Education, Inc.

Holme, I. M., & Solvang, B. K. (1997). *Forskningsmetodik: Om kvalitativa och kvantitativa metoder* (Vol. 2). (B. Nilsson, Trans.) Studentlitteratur.

Jacobsen, D. I. (2002). *Vad, hur och varför?: Om metodval i företagsekonomi och andra samhällsvetenskapliga ämnen* (Vol. 1:7). (C. Hellström, Ed., & G. Sandin, Trans.) Studentlitteratur.

Johnson, G., Scholes, K., & Whittington, R. (2008). *Exploring Corporate Strategy* (Eigth edition ed.). Essex: Pearson Education Limited.

Kvale, S. (1997). *Den kvalitativa forskningsintervjun* (Vol. 1:17). Studentlitteratur.

Kiel-Canal.org. (n.d.). Retrieved October 18, 2010, from Transit Expense: http://www.kiel-canal.org/english.htm

Krugman, P., & Wells, R. (2005). *Microeconomics.* New York: Worth Publishers.

Lantmännen. (2010d). *Välkommen till Lantmännens Identitetsmanual*. Retrieved September 24, 2010, from Identitetsmanual för Lantmännen: http://www.lantmannen.designmanual.se/

Lantmännen. (2010h). *Business Areas*. Retrieved September 28, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/Business-Areas/

Lantmännen. (2010b). *Business Concept*. Retrieved September 24, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/About-the-Group/About-Lantmannen/Vision-and-Business-Concept/

Lantmännen. (2010g). *Companies & Brands*. Retrieved September 28, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/Companies--Brands/

Lantmännen. (2010e). *Lantmännen today*. Retrieved September 24, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/About-the-Group/About-Lantmannen/History/Lantmannen-today/

Lantmännen. (2010a). *Market and position*. Retrieved September 22, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/About-the-Group/About-Lantmannen/Market-and-position/

Lantmännen. (2010c). *Our Company History*. Retrieved September 24, 2010, from Lantmännen Identity Manual: http://www.lantmannen.designmanual.se/eng/brand/history/

Lantmännen. (2010f). *Organization*. Retrieved September 28, 2010, from Lantmännen: http://www.lantmannen.com/en/Lantmannen-COM/About-the-Group/Organization/

Lantmännen. (2009, April 20). Rapport om Lantmännens Sjöfartslogistik.

Lambert, D. M. (2008). *An Executive Summary of SUPPLY CHAIN MANAGEMENT Processes, Partnerships, Performance* (3rd Edition ed.). Supply Chain Management Institute.

Makridakis, S., Wheelwright, S. C., & Hyndman, R. J. (1998). *Forecasting methods and applications* (Third Edition ed.). New York: John Wiley & Sons Inc.

Mooney, C. Z. (1997). *Monte Carlo simulation.* Thousand Oaks, CA, USA: SAGE Publications, Inc.

OMCC Thailand. (n.d.). Retrieved October 2010, from http://www.omccthailand.com/webboard/shipsale.php

Person within Lantmännen. (2010, September). Interview A. (J. Odland, & F. Kaltea, Interviewers)

Seppä, L. (2010, September 2). Lantmännen: Sjötransporter – bakgrund & status.

Shipbroker. (2010, September). Interview B. (F. Kaltea, & J. Odland, Interviewers)

Shipowner. (2010, September). Interview C. (F. Kaltea, & J. Odland, Interviewers)

Sjöfarsverket. (n.d.). Retrieved October 13, 2010, from http://www.sjofartsverket.se/

Stopford, M. (2009). *Maritime Economics* (3rd Edition ed.). New York, NY, USA: Routledge.

Tully, S., & Sookdeo, R. (1995). PURCHASING'S NEW MUSCLE. *Fortune , 131* (3), 75-81.

THOMSON REUTERS. (2010). *THOMSON REUTERS DATASTREAM.* Retrieved December 17, 2010, from http://thomsonreuters.com/content/financial/pdf/i_and_a/datastream_corporate.pdf

Appendix A – Indices

Code	Candidate Factor Name	Indices
S1	Number of new built ships	18 indices indicating ship building activities in major countries
S2	Number of ships sold to different market	Not available
S3	Number of ships scrapped	Not available
S4	Number of ships laid up	Not available
D1	Deep sea freights	5 indices from Baltic Exchange
D2	World Economy Growth	14 Export/Import indicies for mayour countries 10 Stock Indices
D3	Chinese Import/Export Activity	10 Chinese Import/Export indicies 8 Chinese Stock Indices
D4	Steel Industry	8 Metal Price/Steel Production/Mining activity indices
D5	Coal Industry	1 Coal Production Index
D6	Energy Industry	5 Electricity Price/Electriciy Production Indicies
D7	Mineral Industry	3 Salt/Stone/Mineral Production Indices
D8	Wood Industry	3 Wood Production/Forestry Products Price/ Pulp and Paper Volume Indices
D9	Wind Power Industry	Not available on industry level
D10	Agriculture Industry	2 Harvest Indices
D11	Construction Industry	4 Construction Market Indices
D12	Other Industries	4 Total Industrial Production Indices
D13	Grain Price	32 different price indices
D14	Ore Price	1 Iron & Steel Price Index
D15	Coal Price	1 Coal Price Index
D16	Cokes Price	1 Coke Products Volume Index
D17	Scrap Metal Price	3 Scrap Metal Price Indices
D18	Fertilizers Price	1 Fertilizer Index
D19	Stone Price	2 Stone Price Indices
D20	Salt and Minerals Price	2 Salt Price Indices
D21	Wood Price	2 Pulp/Wood Price Indices
D22	Other Commodity Prices	12 General Commoditiy Price Indices
Code	Candidate Factor Name	Indices
CV1	Bunker	Bunker Oil, 380 cst, Rdam U$/MT Bunker Oil, 180 cst, Rdam U$/MT Bunker Oil, 180 cst, Piraeus U$/MT OPEC Oil Basket Price U$/Bbl

Other cost related indices	Indices
Interest rate indices	EURO AREA BOND YIELD CORPORATE (ECON) - MIDDLE RATE SWEDEN BOND YIELD CORPORATE (ECON) - MIDDLE RATE EURO AREA BOND YIELD GOVT.2 YR (ECON) - MIDDLE RATE EURO AREA BOND YIELD GOVT.10YR (ECON) - MIDDLE RATE SWEDEN BOND YIELD GOVT.10 YR(ECON) - MIDDLE RATE EURO REPO BENCHMARK 3 MTH (EUR:FBE) - MIDDLE RATE EURO REPO BENCHMARK 6 MTH (EUR:FBE) - MIDDLE RATE EURO REPO BENCHMARK 9 MTH (EUR:FBE) - MIDDLE RATE UK INTERBANK 1 YEAR - MIDDLE RATE UK INTERBANK 3 MONTH - MIDDLE RATE UK LOCAL AUTHORITY DEPOSIT 1 YEAR - MIDDLE RATE UK LOCAL AUTHORITY DEPOSIT 3 MONTH - MIDDLE RATE EURO MARGINAL LENDING (ECB) - MIDDLE RATE EURO OVERNIGHT DEPOSIT (ECB) - MIDDLE RATE EURO MAIN REFIN. OPERATIONS (ECB) - MIDDLE RATE EUROSYS L-T REFI - MARGINAL - MIDDLE RATE EURIBOR 12 MONTH - OFFERED RATE EURIBOR 12 MONTH (ACT/365) - OFFERED RATE EURIBOR 3 MONTH - OFFERED RATE EURIBOR 3 MONTH (ACT/365) - OFFERED RATE SWEDEN INTERBANK 1 YEAR - MIDDLE RATE BELGIUM BENCHMARK BOND 10 YR (DS) - RED. YIELD GERMANY BENCHMARK BOND 10 YR (DS) - RED. YIELD GR BANK LENDING RATES TO PRIVATE SECTOR: SHIPPING (EP) CURN
Exchange rate indices	EMEXCHANGE RATE - US DOLLAR PER EURO (AVERAGE) EMEXCHANGE RATE - JAPANESE YEN PER EURO (AVERAGE) EMEXCHANGE RATE - UK POUND PER EURO (AVERAGE) EMEXCHANGE RATE - SWEDISH KRONA PER EURO (AVERAGE)
Inflation rate indices	EA ANNUAL INFLATION RATE - EUROZONE BG INFLATION RATE NADJ BD INFLATION NADJ SD OFFICIAL RATE OF INFLATION NADJ UK INFLATION RATE FOR HARMONISED CPI NW CPI - ANNUAL % CHANGE NADJ FR ANNUAL INFLATION RATE NADJ DK INFLATION RATE NADJ FN INFLATION RATE (2005=100) NADJ NL CPI (ANNUAL INFLATION RATE)

Code	Candidate Factor Name	Indices
S1	Number of new built ships	CH OUTPUT OF INDUSTRIAL PRODUCTS - CIVILIAN SHIPS VOLN CH INDL. PROD - CIVIL-USE STEEL SHIPS (% Y/Y)(CMLV.)NADJ CH OUTPUT OF INDL. PRODUCTS - CIVIL-USE STEEL SHIPS(CMLV) VOLN CH INV. IN FIXED ASSETS: TRANSPORTATION - WATER (CMLV) CURN JP INDUSTRIAL PRODN. - SHIPS & MARINE COMBUSTION ENGINES VOLA JP ORDERS VALUE - SHIP CURN JP ORDERS BACKLOG VALUE, SHIP CURN JP MACHINERY ORDERS: MFG. - SHIP BUILDING CURA US AVG OVERTIME HOURS PROD WRKRS - SHIP AND BOAT BUILDING VOLN US AVG WKLY HOURS - SHIP & BOAT BUILDING VOLN IT INDL. PRDN. - BUILDING & REPAIRING OF SHIPS & BOATS VOLN IN INDUSTRIAL PRODUCTION - SHIP BUILDING AND REPAIRCURN BR INDUSTRIAL PRODUCTION: BUILDING & REPAIRING OF SHIPS VOLN EX INDUSTRIAL PRODUCTION: BUILDING OF SHIPS & BOATS VOLN EK NEW ORDERS: BUILDING OF SHIPS & BOATS VOLA BD NEW ORDERS: BUILDING OF SHIPS & BOATS VOLN GR NEW ORDERS: BUILDING OF SHIPS & BOATS VOLA NL NEW ORDERS: BUILDING OF SHIPS & BOATS VOLN
S2	Number of ships sold to different market	Not available
S3	Number of ships scrapped	Not available
S4	Number of ships laid up	Not available
D1	Deep sea freights	Baltic Exchange Dry Index (BDI)

		Baltic Exchange Supramax Index Baltic Exchange Supramax Index Baltic Exchange Handysize Index Baltic Exchange Panamax Index
D2	World Economy Growth	SD CPI NADJ (KPI) SD EXPORTS VOLA SD IMPORTS VOLA OP IMPORTS OF PETROLEUM - TOTAL OPEC VOLN EM EXTRA-EMU EXPORTS (SA) CURA EM EXTRA-EMU IMPORTS (SA) CURA NL EXPORTS (FOB) CURN NL IMPORTS (CIF) CURN BD IMPORTS CIF (PAN BD M0790) CURA BD EXPORTS FOB (PAN BD M0790) CURA UK IMPORTS CURN UK EXPORTS CURN ES EXPORTS CONA ES IMPORTS CONA S&P1500 MARINE OMX STOCKHOLM 30 (OMXS30) NYSE COMPOSITE DOW JONES INDUSTRIALS FTSE 100 NIKKEI 225 STOCK AVERAGE AMEX CHINA SHANGHAI SE A SHARE BNY MELLON CHINA ADR NASDAQ 100
D3	Chinese Import/Export Activity	CH INDUSTRIAL PRODUCTION INDEX VOLN CH IMPORT PRICE INDEX NADJ CH IMPORTS CURN CH IMPORTS (UNREVISED) CURN CH EXPORTS (UNREVISED) CURN CH EXPORT PRICE INDEX NADJ CH EXPORTS CURN CH CARGO HANDLED AT MAJOR SEAPORTS - FOREIGN CARGO VOLN CH VOLUME OF FREIGHT - WATERWAYS (TON-KILOMETER) VOLN CH FREIGHT TRAFFIC - WATERWAY VOLN DOW JONES CHINA BROAD MKT INDEX AMEX CHINA BNY MELLON CHINA ADR HSBC CHINA INDEX E S&P CHINA BMI :G E TR CHINA DOM FL L BNP PARIBAS CHINA INDEX SHANGHAI SE A SHARE
D4	Steel Industry	CRB Spot Index Metals - PRICE INDEX LME-Steel Med. Total Turnover - TURNOVER EURO STOXX TM IND MET&MINING E STOXX EUROPE TMIND MET&MINING E STOXX EUROPE TM MINING E - PRICE INDEX G12-DS General Min - PRICE INDEX SD INDUSTRIAL PRODUCTION - BASIC METALS VOLN WD WORLD - STEEL PRODUCTION VOLN
D5	Coal Industry	EUROPE-DS Coal
D6	Energy Industry	Nordpool-Electricity Avg Reference EEX - Phelix Base Hr.01-24 E/Mwh NordPool-N.Norway Avg. NOK/MWh NordPool-W.Denmark Avg. NOK/MWh NordPool-Finland Avg. NOK/MWh
D7	Mineral Industry	EX INDUSTRIAL PRODN.: MINING & QUARRYING - SALT EXTRACTION VOLN UK IMPORTS - SALT, SULPHUR, EARTHS & STONE CURN UK EXPORTS INTRA EU - SALT, SULPHUR, EARTHS & STONE CURN
D8	Wood Industry	DEVELOPED MKTS.-DS Forestry - PRICE INDEX SD INDUSTRIAL PRODUCTION - WOOD & WOOD PRODUCTS VOLN SD INDUSTRIAL PRODUCTION - PULP, PAPER, ETC VOLN
D9	Wind Power Industry	Not available on industry level
D10	Agriculture Industry	TR Equal Weight CCI Grains & Oilseed Yearly Swedish Harvest

D11	Construction Industry	EURO STOXX TM CON & MAT E EUROPE-DS Build Mat/Fixt G12-DSBuild Mat/Fixt CHINA A-DS Build Mat/Fixt
D12	Other Industries	EK INDUSTRIAL PRODUCTION EXCLUDING CONSTRUCTION (EA16) VOLA SD INDUSTRIAL PRODUCTION - MINING & MANUFACTURING VOLA BD INDUSTRIAL PRODUCTION INCLUDING CONSTRUCTION VOLA JP TERTIARY: FREIGHT TRANSPORT - WATER, COASTWISE NADJ
D13	Grain Price	Cocoa-ICCO Daily Price US$/MT Corn No.2 Yellow Cents/Bushel Cotton,1 1/16Str Low -Midl,Memph C/Lb Coffee-Brazilian (NY) Cents/lb Rubber (MRE) SMR GP FOB Sen/Kg Rice,Thai L/Grn 100% B Grade FOB,$/MT Soyabeans, No.1 Yellow C/Bushel Wheat, No.2 Hard (Kansas) Cts/Bu Soyameal USA 48% Protein $/MT Soya Oil, Crude Decatur Cents/lb Raw Sugar-ISA Daily Price c/lb SunflowerseedOil-FOB Rdam Crude £/MT Tea-Colombo MD GR BOPS , CR/KG Wheat No.2,Soft Red Cts/Bu Wool AWEX E.M.I. Aus.C/KG Apricots-Turkish Whole No4 CIF UK Barley ICE Futures Canada M C$/MT Cashew Kernals-India Spot 320S £/MT Pepper Ship Sarawak White Faq CIF Pepper(Black)Sarawak Spot $/MT Walnuts-China Light Halves £/MT Lard-UK Ex Works £/MT Tallow Max 15% Ffa Del Rdam Rapeseed Meal-EU 34% Protein/Oil £/MT Sunflowerseed Meal- EU 29% Ex Store Nylon Yarn 70D TW/kg Acid Oils-Palm Acid FOB Malaysia Castor Oil-Origin Ex Tank Rdam Cottonseed Oil-US Crude Missisippi Palm Kernal Oil- Refined,UK £/MT Palm Oil-Malaysian Rdam U$/MT Rapeseed Oil-Crude FOB R'dam £/MT
D14	Ore Price	G12-DS Iron & Steel - PRICE INDEX
D15	Coal Price	G12-DS Coal - PRICE INDEX
D16	Cokes Price	EK INDUSTRIAL PRODN.: MANUFACTURING - COKE OVEN PRODUCTS VOLA
D17	Scrap Metal Price	HSBC GLOBAL SCRAP STEEL E - PRICE INDEX HWWI Iron Ore, Steel Scrap EU EUR - PRICE INDEX US IRON & STEEL SCRAP NADJ
D18	Fertilizers Price	EX INDL.PROD.: MINING & QUARRYING-CHEM & FERTILIZER MINERALS
D19	Stone Price	SD PPI: MINING & QUARRYING - STONE, SAND & C LAY NADJ ES PPI: MINING & QUARRYING - STONE, SAND & C LAY NADJ
D20	Salt and Minerals Price	JP CPI: SALT NADJ IT CPI: FOOD - SALT NADJ
D21	Wood Price	NBSK Pulp (CIF W. Europe) U$/MT RL-Western SPF #2& Btr 2X4 R/L Mill
D22	Other Commodity Prices	CX Commodity Index - RETURN IND. (OFCL) MLCX Spot Index - PRICE INDEX DJ UBS-Spot Commodity Index - PRICE INDEX Economist Commodity All Items ($) - PRICE INDEX S&P GSCI Commodity Spot - PRICE INDEX Westpac Commodity Futures Ind - PRICE INDEX DRAMeXchange-DXI Index - PRICE INDEX LME-LMEX Index - PRICE INDEX Rogers International Commodity Ind TR - RETURN IND. (OFCL) ClubCommodity.com COMMIN - PRICE INDEX CRB Spot Index (1967=100) - PRICE INDEX TR Equal Weight CCI - PRICE INDEX

Appendix B – Interview questionnaire

Overall focus: All questions below concerns Dry bulk shipping with ships of approximately 3000 DWT (up to 10 000), in the Northern Europe region – from Netherlands and Germany to and within the Baltic Sea.

Dry Bulk Freight Market Overall Information

- About ownership structures for the ships:
  - What are the alternative ownership structures for ships?
  - What is most common?
- How does the freight rate depend on the shipped volume? I.e. how big is the price difference of shipping 1500 and 2500 tons? (On a ship that can hold at least 2 500 tons)
- How much can the loading/unloading time differ between different ships of the same size? (If there are differences why do they occur?)

Lantmännen Shipping purchasing information

- Does LM ever ship goods together with other companies? (i.e. share a ship)
- Are the ships used by LM for one specific route often empty on the return route?
- In what currency are prices listed? Are currency futures used?
- Which requirements does LM have on shipping companies/ships?
  - Credit rating
  - Ship, age, engine, fuel, other environmental issues
  - Ethical, salary, union connection etc.
  - Flag, ownership
  - Is there a "list" of approved suppliers? How are new companies approved?
- Do LM's requirements differ from other sea freight purchasers?
- What transparency exists of the costs for the ship performing a specific freight?
- How are LM's Purchasing process designed?
  - Is there several negotiation periods throughout the year?
  - What kind of contract is used (FOB, CIF, others)?
  - How long in advance is the contract signed?

- In what proportion is the different contract types used?
- Does shipping futures exist? Are such used by LM?

- How seasonal are the shipping needs?

- What effects does a cold winter have (volume, supply, prices etc.)?

- Are there different requirements for different kinds of shipped goods when it comes to, temperature, cargo holds, etc.? Could the below goods be divided into a number of groups with similar requirements?
  - Betfiber
  - Betfor
  - Expro (värmebehandlat rapsmjöl)
  - Havre
  - Korn
  - Lucernpellets
  - Majs
  - Majsgluten
  - Majspellets
  - Melass
  - Melass betfiber
  - Omelasserad betfiber
  - Palm
  - Palmexpeller
  - Rapsmjöl
  - Rapskaka
  - Soja
  - Soypass
  - Soja GMO
  - Solrosexpeller
  - Vete

- Estimate the percentage of ships that can fulfill the requirements for each group.

Shipbroker specific questions

According to your experience:

- Is it common that different freight purchasers are shipping their cargo at the same time (in different cargo holds) on the same ship? (I.e. that the ship contains cargo from more than one freight purchaser)

- Is it common that a ship used by one customer for the route from port A to port B is empty on the return route, or is the ship loaded at (or close by) port B?
  - What is the average utility rate of a ship?
  - When accepting a freight to a port outside the "normal" operation area is the return (or part of return) included in the freight rate?

- What transparency exists for the costs for the ship performing a specific freight (i.e. are the ships ever reporting their actual costs to the shipbrokers/freight purchasers)?

- What effects does a cold winter have on the freight rates for routes in the northern European area?

- How does the freight rate depend on the shipped volume? I.e. how big is the price difference of shipping 1500 and 2500 tons? (On a ship that can hold at least 2 500 tons)

Sea freight Cost factors

- About ownership structures for the ships:
    - What are the alternative ownership structures for ships?

- What is most common?

- **List the different costs a shipping company/ship have when transporting cargo from port A to port B.** (Please list as many as possible)

- What costs are dependent on the age of ship?

- What costs are directly dependent on the specific port?

Discuss the following costs:

- Fasta kostnader
    - Försäkring
    - Besättning
    - Proviant
    - Kapitalkostnader
        - Avskrivningar
        - Räntor
- Rörliga kostnader
    - Bränslekostnader (bunker?)
    - Hamnavgift
        - Kajavgift
        - Lotsning
        - Renhållningsavgift
        - Grundpenning och trossföring
        - Bogsering
    - Kanalavgift

- Fyravgift
- Farledsavgift
- Utsläpp/miljöavgift (reducerar farledsavgift?)
- Underhållskostnader

Demand/supply factors

- What are the factors affecting the **supply** of ships in this region? (Give as many alternative factors as possible)

- What is your opinion on the nature of the **supply** (i.e. is it steady/volatile, small/large etc.)?

- What are the factors affecting the **demand** for these kinds of ships? (Give as many alternative factors as possible)
- How seasonal is the **demand**?

- What is your opinion on the **demand** in the market – steady/volatile, small/large etc.

- Are there any existing indices that have a high correlation with the freight rates for this specific type of transports?

- How are offered freight rates created – from a shipowner's perspective?

Appendix C – Ship Classification

Class	Low DWT	High DWT	Crew Size	Yearly Crew Salary	Booked Value	Maintenance	Insurance	Commercial Mgmt	Technical Mgmt
1	400	1200	4	48000	0	90000	10000	25000	25000
2	1201	1600	5	47250	106793	100000	30000	25000	25000
3	1601	2400	6	46875	291445	110000	40000	25000	25000
4	2401	3000	7	46500	476098	120000	50000	25000	25000
5	3001	4000	8	45750	1135798	150000	70000	25000	25000
6	4001	5000	9	45000	2731470	160000	85000	25000	25000
7	5001	6000	10	44250	3321812	180000	100000	25000	25000
8	6001	7000	11	43500	3906198	195000	110000	25000	25000
9	7001	8000	12	42750	4484672	205000	120000	25000	25000
10	8001	9000	13	42000	5057279	220000	130000	25000	25000

Bunker Consumtion (tonkm/liter)	Unloading (tons/day)	Loading (tons/day)	Speed	Days on sea per year	Fill rate	Södertälje Canal (SEK)	Trollhätte Canal (SEK)	Kiel Canal
110	1000	3000	8	270	90%	18159	22113	1023
140	1100	3000	8,5	270	90%	23213	28000	1310
165	1150	3000	8,8	270	90%	25897	31402	1479
190	1200	3000	9	270	90%	28581	34804	1647
195	1300	3000	9,5	270	90%	32055	39034	2075
200	1400	3000	10	270	90%	37424		3107
210	1500	3000	10,5	270	90%	42793		3900
215	1600	3000	11	270	90%	42793		4700
220	1700	3000	11,5	270	90%	42793		5500
225	1800	3000	12	270	90%	48162		6300

For explanations and references for the table, see next page.

References for Ship Classification

Class: The ships were divided into 10 different classes based on their size in DWT.

Low DWT: The lower DWT limit for each class.

High DWT: The higher DWT limit for each class.

Crew Size: The estimated crew size for the different ship classes. (ITF, 2008), (Stopford, 2009), (Shipowner, 2010)

Yearly Crew Salary: The estimated total costs for all crew in each class in Euro. This number includes taxes and social fees. (ITF, 2008), (Stopford, 2009), (Shipowner, 2010)

Booked Value: The estimated average booked value of the ships in each class, in Euro. This number was calculated based on the average age for each class, combined with the estimated original value and a standard depreciation plan. (OMCC Thailand), (Stopford, 2009)

Maintenance: The average yearly maintenance cost in Euro per year. These numbers are based on the age of the ships. (Shipowner, 2010), (Shipbroker, 2010), (Stopford, 2009)

Insurance: The average insurance premium for the ships in each class, in Euro per year. (Shipowner, 2010), (Shipbroker, 2010), (Stopford, 2009)

Commercial Management: The cost of making sure that the ship is being offered to the market, by keeping in touch with shipbrokers and transportation purchasers. (Shipowner, 2010), (Shipbroker, 2010), (Stopford, 2009)

Technical Management: The cost of making sure that all technical aspects of the ship is functioning. For example hiring crew, book-keeping, handling invoices, arranging repairs and maintenance. (Shipowner, 2010), (Shipbroker, 2010), (Stopford, 2009)

Bunker Consumption: The estimated average bunker consumption for each ship class. The number is based on an extensive study of the listed fully loaded consumption rates for a large number of boats. (Shipowner, 2010), (Shipbroker, 2010), (Stopford, 2009), (OMCC Thailand)

Unloading: The average unloading speed for each ship class, where larger ships have an higher speed because of the possibility to perform several unloading operations simultaneously. (Person within Lantmännen, 2010), (Shipbroker, 2010), (Stopford, 2009)

Loading: The average loading speed for each ship class. This is assumed similar for all ship classes since most ports used by Lantmännen have a fixed loading capacity. (Person within Lantmännen, 2010), (Shipbroker, 2010), (Stopford, 2009)

Speed: The average speed of the ships of each class, depending on the size and age of the ships. Again these numbers are based on an extensive study of the listed speeds for a large number of boats of different ages and sizes. (Stopford, 2009), (OMCC Thailand), (Shipowner, 2010)

Days on sea per year: The total number of business days for ships in the different classes. This number of days are hence the days that the ships get paid and the days which the fixed costs is divided upon. (Stopford, 2009), (Shipowner, 2010)

Fill rate: The average loading capacity of all ships is assumed to be 90 % of their DWT. This is based on an extensive evaluation of all shipments performed by Lantmännen. In the cases where the ships have loaded more than 90 % of DWT this higher number have been used as their maximum capacity. This was based on an investigation of the data received from Lantmännen. (Person within Lantmännen, 2010)

Södertälje Canal: The estimated fee for travelling with pilot through the canal, in SEK. (Sjöfarsverket)

Trollhätte Canal: The estimated fee for travelling with pilot through the canal, in SEK. There is a limitation on the size that is leaving out the five largest classes. (Sjöfarsverket)

Kiel Canal: The fee for travelling on the Kiel Canal, based on example boats for each ship class. The example boats were chosen on the criteria of being in the middle of the DWT interval and of having an age close to the average age of the ship. (Kiel-Canal.org)

Appendix D – Port Classification

List of ports	Time to enter port (hours)	Fee per gross ton	Fee per GT second	Second condition GT	Fee per GT third	Third Condition GT	Fee per Cargo weight	Fee per RT	Fee per RT second	Second Cond RT	Currency
Aalborg	2	2,25	2,76	5001	3,28	10001					DKK
Amsterdam	2	0,291					0,467				E
Amsterdam/Rotterdam	2	0,291					0,467				E
Aveiro	2	0,1896					0,1923				E
Brake	2	0,1117	0,203	3900							E
Bremen	2	0,1194									E
Brest	2	0,291					0,467				E
Brunsbüttel	2	0,093	0,195	4000							E
Cadiz	2	0,3066									E
Cartagena	2	0,3746									E
Cork	2	0,5									E
Delfzilj	2	0,257					0,167				E
Dordrecht	2	0,291					0,467				E
Dundee	2	0,5									E
Eemshaven	2	0,257					0,167				E
Falkenberg	2	2									SK
Flensburg	2						0,2				E
Fredrikstad	2	0,95									NK
Gdansk	2	0,45									E
Gdynia	2	0,49									E
Ghent	2	0,5304									E
Gijon	2	0,3684									E
GranCanaria	2	0,3984									E
Hamburg	2	0,093	0,195	4000							E
Hamburg/Brake	2	0,093	0,195	4000							E
Heiligenhafen	2							0,12	0,2	1500	E
Helsingborg	2	4									SK
Holbaek	2	0,05									E
Holmsund	2	2									SK
Horsens	2	3,68									DKK
Horten	2	0,8	0,7	2000	0,6	3000					NK
Husum	2	0,093	0,195	4000							E
Kalmarsand	2	3,42									SK
Karlshamn	2	4,25									SK
Kiel	2							0,12	0,2	1500	E
Klaipeda	2	2									LTL
Klintehamn	2	3,1									SK

Kolding	2	3,76								DKK
Köge	2	0,05								E
Köping	2	4,5								SK
Liepaja	2	2								LTL
Leixöes	2	0,1709								E
Lidkoping	2	2								SK
Lissabon	3	0,1622								E
LondonDerry	2	0,5								E
Lubeck	2							0,12	0,2	1500	E
Malaga	2	0,3066								E
Malmö	2	4,9								SK
Marin	2	0,3795								E
Moss	2	0,95								NK
Motril	2	0,3795								E
Naantali	2	0,25								E
Norrköping	2	2								SK
Nyköping	2	2								SK
Odense	2	0,05								E
Oldenburg	2	0,1194								E
Ponta Delgada	2	0,173								E
Randers	2	3,76								DKK
Rauma	2	0,25								E
Rendsburg	2							0,12	0,2	1500	E
Rostock	2							0,12	0,2	1500	E
Rotterdam	3	0,303								E
Ruisbroek	2	0,5592								E
Sevilla	4	0,2588								E
Skattkärr	2	2								SK
Stockholm	2	3,42								SK
Stralsund	2	0,07	0,1	1500	0,13	2500				E
Strängnäs	2	4,5								SK
Szczecin	2	0,45								E
Södertälje	2	3,1								SK
Tarragona	2	0,372								E
Teneriffa	2	0,3984								E
Uddevalla	2	3,4								SK
Vejle	2	3,76								DKK
Vierow	2	0,05								E
Wolgast	2	0,2								E
Vasteras	2	4,5								SK
Ystad	2	3,9								SK

Zwijndrecht	2	0,303									E
Åhus	2	4,25									SK
Nyköbing	2	0,05									E
Wismar	2							0,12	0,2	1500	E

Appendix E – List of Ships

Name	DWT	Build year	Flag	GT
Adriane	1307	1970	Denmark	1371
AKAI	2785	1985	Antigua	2740
Ala	1205	1968	Panama	1064
ALANA	5049	1999	Antigua	2999
Aleksandr Sibiryakov	7075	1989	Malta	6395
Alexander Kuprin	3030	1996	Malta	2319
Alexander S	3352	1967	Russia	2478
ALLEGRETTO	4568	2006	Antigua	3128
Alva	1335	1968	Panama	1037
Amore	1276	1988	Cyprus	851
Amur 2520	3254	1987	Russia	3086
Amur 2525	3332	1988	Russia	3086
Amur 2531	3332	1989	Russia	3081
Anders Rousing	1565	1979	Denmark	1324
Andrina F	1890	1990	Antigua	1568
ANDROMEDA	3152	1983	Antigua	1908
Anette	1600	1979	Norway	1713
Anke Angela	1735	1984	Gibraltar	1547
Anmar S	1590	1993	Netherlands	1666
ANNA MARIE	3406	1996	Antigua	2345
ANNE S	3471	1997	Netherlands	2375
Annemarie	1190	1967	Germany	1064
Annette	1600	1979	Norway	1713
ANTABE	3702	1997	Gibraltar	2446
Antares	1576	1984	Netherlands	1172
ANTJE K	4250	2002	Netherlands	3037
ANTONIA	4646	1983	Antigua	3780
Arctica	2324	1984	Bahamas	1532
Aressa	2649	1978	Russia	1926
ARKLOW ROVER	4530	2004	Ireland	2999
Arngast	1030	1958	Germany	833
ARTISGRACH	12150	1990	Netherlands	7949
Arundo	2892	1985	St Vincent	1957
Atlantica Hav	2309	1982	Bahamas	1514
Balder	2800	1986	Antigua	1790
Baltic Breeze	585	1952	Panama	397
Baltic Carrier	3130	1997	Gibraltar	2280
Baltic Merchant	3110	1997	Gibraltar	2280
Baltic Sailor	3110	1998	Gibraltar	2280
Baltic Wind	635	1970	Denmark	465
Baltica Hav	2305	1983	Bahamas	1528
Baltiyskiy 101	2649	1977	Russia	1926
Baltiyskiy 102	2557	1978	Russia	1926
Baltiyskiy 108	2649	1979	Dominica	1987
Baltiyskiy 109	2649	1980	Dominica	1929
Baltiyskiy 110	2554	1980	Russia	1926
Baltiyskiy 202	2803	1994	Malta	2264
BARBARA D	624	1966	Poland	409
Barentszee	1536	1973	Netherlands	1045
Berit	2516	1996	Gibraltar	1864
Beta	1190	1967	Germany	1064
Birthe Bres	3740	2007	Denmark	2680
Blue Bird	1300	1971	Unknown	1115
BORNRIF	2600	1996	UK	1882
BOTNIA	8317	2008	Antigua	5281
Brake	817	1957	Tuvalu	603
BRIGGA	4216	1994	Antigua	2818
Britannica hav	2369	1985	Malta	1521
Brithe Bres	3740	2007	Denmark	2658
Cabrana	2075	1988	Belize	1853
CAPELLA	3792	1999	Gibraltar	2780
Carissa	2627	1988	Finland	1986
CAROLIN G	3850	2008	Antigua	2545
CAROLINA	3697	2008	Netherlands	2396
Carolyn	2330	1974	Denmark	1872
CATHY JO	6000	2008	Netherlands Antilles	3990
CECILIA	7488	2005	Antigua	5581
Cedar	1766	1981	Antigua	1499
Ceg Cosmos	1300	1983	Gibraltar	1139
CEG GALAXY	1063	1983	Antigua	1035
Celica	1151	1979	St Vincent	813
Celina	2250	1992	Finland	1559
Celtica Hav	1904	1984	Bahamas	1521
Christa Kerstin	2416	1977	Belize	1768
Cindia	7594	2005	Antigua	5581
Clarity	1395	1981	St Vincent	986
Cleopatra	2954	1982	Finland	1999
Dana 1	1885	1973	Georgia	1494
DANIA KIRSTEN	3100	1976	Denmark	1882
Danica Hav	2310	1984	Bahamas	1536
Danubia	2550	1984	Norway	1781
DC MERWESTONE	3142	1974	Netherlands	2973
Defender	2190	1979	St Vincent	1512

Delfin	3700	1998	Gibraltar	2780
Diamonde	2475	1985	St Vincent	1487
DINTELBORG	8865	1999	Netherlands	6235
Don 4	4400	1997	Malta	3796
DONITA	4150	1982	St Vincent	3632
Drawa	1870	1978	Poland	1575
EDGAR LEHMANN	12000	2007	Antigua	8491
EEMS Coast	1490	1985	Netherlands	998
Eems Delfia	1528	1985	Netherlands	1132
Elizabeth F	1686	1991	Netherlands	1276
Elke	2127	1985	Antigua	1473
Elke D	1538	1988	Antigua	1307
Elsebeth	2267	1986	Antigua	1636
ELVI KULL	1163	1979	Antigua	741
EMS	5409	2007	Antigua	3766
Ems Majestic	3420	1996	Antigua	1999
emsbroker	5917	2002	Germany	4183
EMSRUNNER	5499	2006	Cyprus	4102
Eric Hammann	1323	1991	Germany	1156
Erlanda	3015	1991	St Vincent	1999
Ewald	2262	1999	Antigua	1599
Evert Prahm	2390	1996	Germany	1598
Fast Julia	2285	1985	Belgium	1391
Faustina	3015	1990	St Vincent	1999
Faxborg	1190	1968	Denmark	924
Fehn Capella	2503	1996	Antigua	1682
Fehn Cartagena	1550	1984	Gibraltar	1372
Fehn Coral	1800	1991	Antigua	1559
FINEX	9857	2001	Germany	6375
Flinterbright	3475	2004	Netherlands	2474
Flinterjute	4537	2008	Netherlands	2999
Flinterlinge	3300	2000	Netherlands	2548
Flinterzee	6075	1997	Netherlands	4368
FREDO	1631	1985	Germany	1649
Freyfaxi	1397	1966	Panama	1133
Fri River	3260	1991	Antigua	1981
Fri Sky	1766	1981	Bahamas	1511
Frida	1901	1985	Finland	1587
FRIGGA	4216	1994	Antigua	2818
GEISE	4299	2006	Gibraltar	3198
Gerda	1300	1989	Latvia	852
Germanica Hav	1717	1984	St Vincent	1566
Gina R	1426	1971	Georgia	1773
Global 1	3793	1999	Lithuania	2451
GLOBAL HELENA	7448	2009	Antigua	5164
global hemera	7000	2008	Antigua	5164

Globia	1622	1979	St Vincent	1095
Glory	2155	1979	Russia	1590
Gorland	500	1966	Panama	292
GOTLAND	3035	1984	Germany	1860
GRETA C	13517	2009	Isle of Man	9177
GRIMM	4175	1992	Germany	3564
HAJO	4650	1991	Antigua	3818
Halland	2295	1986	Germany	1899
Hannelore	719	1965	Germany	658
Hav Zander	3000	1990	Bahamas	1960
Heike Lehmann	3050	1985	Antigua	2564
Heinrich G.	3694	1997	Antigua	2446
HELA	1085	1966	Germany	861
HELENIC	3150	2008	Netherlands	2281
Helga	2280	1984	Finland	1472
Hellevik	1371	1975	Sweden	1957
Helse	2378	1992	Antigua	1582
Hendrik S	3200	2001	Netherlands	2311
Hendrika Margaretha	3200	1993	Netherlands	1999
Hera	1300	1975	Germany	1202
Hertfordshire	2489	1995	Gibraltar	1864
Iberica Hav	2300	1999	Bahamas	1599
Ida	2019	1986	Cyprus	1616
ILKA	1300	1985	Germany	1366
INA	1670	1978	Poland	1589
Indian	2845	1975	Norway	1920
Ingeborg Pilot	1053	1981	Norway	1196
Ivan Bobrov	3182	1978	Russia	2359
Izborsk	2155	1978	Belize	1590
Jan D	3260	1991	Antigua	1981
JANIS	3180	1975	Russia	2450
JOHANNE	4570	1998	Malta	2748
Jolanda	964	1956	Antigua	499
Jongleur	3030	1991	St Vincent	1999
Julietta	10610	2002	Antigua	7406
JUTTA-B	580	1965	Germany	637
Jütland	1550	1978	Germany	1495
Jytte Bres	4748	1999	Denmark	2876
KAIE	4161	1990	Malta	2374
Kaisa	4528	2005	Malta	3183
karin lehman	4071	2000	Antigua	2820
Karina W	1113	1983	Germany	658
Katharina Siemer	3357	1985	Cyprus	2061
KATRE	4173	1991	Malta	2497
KATRIN	4139	1986	Antigua	3448
Kelarvi	2300	1995	Russia	1596

Kento	2300	1994	Panama	1596
Keret	2300	1994	Russia	1596
Kevin S	2200	1984	Antigua	1372
KLAIPEDA	3697	1995	Lithuania	2395
Kliftrans	3132	1997	Netherlands	2224
KOLLUND	4170	1994	Cyprus	2818
Koriangi	2300	1993	Panama	1596
KORMORAN	743	1965	Cook Islands	658
Kovera	2300	1995	Russia	1596
Kuban	2155	1980	St Vincent	1639
Ladoga 101	2075	1988	Russia	1853
Ladoga 102	2075	1988	Belize	1853
Ladoga 103	2075	1988	Russia	1853
Ladoga 3	2201	1973	Belize	1511
Ladoga 5	2201	1973	Belize	1511
Ladoga 8	2180	1974	Belize	1511
Lady Nolan	2000	2002	Netherlands	1978
Lady Nona	2117	2002	Netherlands	1978
Lady Nova	2117	2002	Netherlands	1978
Lamaro	1769	1972	St Vincent	1282
LAMMY	3500	2010	Netherlands	1986
LANDIA	1964	1969	St Vincent	1208
Langeland	2287	1985	Germany	1832
LARA	5500	1998	Netherlands	3954
Largo II	711	1973	France	531
Largona	1195	1978	St Vincent	866
Lechia	2075	1988	Poland	1853
LEESWIG	4515	1996	Antigua	2901
Leona	1900	1987	Germany	1593
Leonid Leonov	2800	1995	Malta	2264
Leonid Sobolev	25680	1985	Russia	16502
Lezhevo	2300	1995	Russia	1596
Lian	2723	1975	St Vincent	1497
Lifana	1424	1983	Netherlands	1116
Linda Marijke	1850	1992	Netherlands	1539
Lisa D	1685	1984	Antigua	1162
Lisa S	1400	1968	Antigua	872
Lister	4113	1997	Gibralta	2863
Listerland	4021	1994	Sweden	2735
Listervik	3905	1996	Gibraltar	2863
LITTLE JANE	1276	1988	Netherlands	851
Little Star	1680	1985	Georgia	1697
Liv Kristin	2348	1984	Gibraltar	1843
Lolland	2668	1981	Germany	1811
Lona	2958	1972	St Vincent	1861
Lone Bres	4748	2000	Denmark	2876

Lore D	1663	1981	Antigua	1127
Lore Prahm	1323	1989	Germany	1156
LUNDEN	1559	1977	St Kitts & Nevis	1055
Magda	2443	2006	Netherlands Antilles	1945
Magda D	1537	1984	Antigua	1298
MALTA CEMENT	3961	1991	Bahamas	2429
Mana	1900	1986	Antigua	1585
MARCEL	3710	1993	Belgium	2449
Mare	2953	2004	Netherlands	2080
Marietje Deborah	3200	2005	Netherlands	2409
Marion K	1663	1981	Antigua	1127
Marlin	1805	2000	Antigua	1499
Medaldan	6798	2009	Cyprus	5335
Meg	2300	1993	Panama	1598
Meridian	1404	1969	Germany	1251
MF RMS Twisteden	2680	2002	Antigua	1898
MIKE	1411	1995	Cyprus	978
Mikhail Dudin	3030	1996	Malta	2319
Mistral	1196	1966	Antigua	1064
Momentum Scan	10000	2010	Netherlands	6525
Monika	3723	1998	Antigua	2446
MONSUNEN	564	1965	Denmark	383
Montis	1631	1985	Germany	1649
Mosvik	2850	1987	Antigua	2236
MUSKETIER	3850	2006	Gibraltar	2545
NAJAD	2240	1978	Gibraltar	2096
Nautica	2166	1992	St Vincent	1587
Nemuna	4156	1998	Antigua	2863
Nina	2723	1987	Finland	1864
Nina 1	1485	1984	St Vincent	998
Nina Bres	3740	2007	Denmark	2658
Nona	2117	2002	Netherlands	1978
Nora	2050	2001	Netherlands	1999
Nord	1891	1991	Netherlands Antilles	1189
Nordic Amanda	3015	1991	Netherlands	1999
Nordic Diana	4180	1996	Netherlands	2774
Nordica Hav	2299	1982	Bahamas	1514
Nordtimber	2400	1972	St Vincent	2463
Norrvik	3254	1979	Isle of Man	2041
Nova	2117	2002	Netherlands	1978
ODERTAL	4507	2007	Antigua	3183
Odinbey	28381	1995	Turkey	16761
Odra	13790	1992	Bahamas	9818
OKAPI	6348	1972	Antigua	4255
OMSKIY 109	3174	1982	Russia	2463
OMSKIY 134	3004	1988	Russia	2544

Onda	3332	1989	St Vincent	3081
Onego	2090	1991	Panama	1574
Oostzee	1114	1978	St Vincent	815
Ora Chelsea	1770	1986	Panama	1473
OSTENAU	3710	2005	Antigua	2461
Passaat	3150	1994	Netherlands	1937
Pavona	370	1951	Sweden	286
Peikko	1723	1983	Cyprus	1521
Perseus	1517	1986	Lithuania	1392
Persus	1517	1986	Lithuania	1392
Piligrim 3	1849	1988	Russia	1551
Poprad	1750	1986	Poland	1567
Porhov	2554	1979	Russia	1926
PORTALEGRE	4672	2009	Madeira (MAR)	2960
Provider	2623	1981	Antigua	1834
RANA EXPRESS	3604	2000	Norway	2528
Rebecca Hammann	2420	1995	Germany	1595
RIA	443	1960	Germany	337
Richelieu	3850	2007	Gibraltar	2545
RIMINI	2600	2008	Netherlands	1862
RIONA	1083	1988	Finland	910
Risoluto	4168	1997	Gibraltar	2848
Rita	2325	1985	Gibraltar	1843
RIVER BLYTH	4850	2000	Antigua	2858
RIVER TYNE	4935	1999	Antigua	2858
RMS BEECK	3246	1995	Antigua	1996
RMS Jurmula	2657	1981	Belize	2363
RMS Lagona	2688	2000	Antigua	1898
RMS Neudorf	2620	1990	Antigua	1985
RMS Rhenus	2688	2000	Antigua	1898
RMS Saimaa	2634	2005	Antigua	2069
RMS Twisteden	2530	2002	Antigua	1898
RMS Wanheim	2620	1990	Antigua	1985
Roger	2171	1984	Antigua	1523
Rona	3502	1977	St Vincent	2351
ROYAL FOREST	31770	1998	Panama	19731
Rubyn	2450	1986	St Vincent	1512
Sally	2770	1977	Norway	1679
Salona	1443	1973	Honduras	886
San Remo	1225	1965	St Vincent	1283
Sandal	2300	1993	Panama	1596
Scanlark	1520	1985	St Vincent	1371
Seg	2300	1993	Panama	1596
Sestroretsk	3484	1980	Russia	3415
Setlark	1572	1983	St Vincent	1281
Siegfried Lehman	2570	1980	Myanmar	2225

SILVES	4671	2008	Madeira (MAR)	2956
Sine Bres	3750	2006	Denmark	2658
Skagern	3171	2000	Netherlands	2301
SKARPOE	4508	2005	Cyprus	3183
Snowlark	1555	1984	St Vincent	1289
Solveig K	2775	1978	Antigua	1678
SOLYMAR	4023	1998	Cyprus	2820
Sormovskiy	3100	1982	Belize	2478
Sormovskiy 3049	3811	1983	Russia	3041
Sormovskiy 3057	3853	1987	Russia	3041
Sormovskiy 50	3346	1985	Russia	2466
Sosnogorsk	3484	1981	Russia	3415
Souyarvi	2300	1994	Panama	1526
Steinau	3712	2006	Antigua	2461
Sternö	1241	1970	Sweden	1300
STK 1012	1669	1985	Russia	1408
Storrington	11990	1982	Isle of Man	7788
Suntis	1815	1985	Germany	1564
Suoyarvi	2300	1994	Panama	1526
Svanur	2600	1983	Norway	1516
Swe-Bulk	3269	1991	Cyprus	2480
Swedica Hav	2276	1986	Bahamas	1616
Swe-Trader	2030	1968	Sweden	1335
SWING	4135	1999	Netherlands	2774
Sydfart	280	1879	Sweden	176
Sylve	3030	1990	Cyprus	1999
Tango	1472	1976	Sweden	1155
Thule	4123	1996	Germany	2842
Time is Money	1130	1973	Netherlands	804
TINA	518	1960	Germany	328
Tinto	1555	1977	Sweden	1191
Tisa	2240	1978	Gibraltar	2096
Tista	2240	1978	Gibraltar	2096
TONJA	864	1957	Honduras	499
Trader	2290	1980	Antigua	1527
Transmar	4138	1998	Antigua	2820
Tulos	2300	1995	Russia	1596
Ugra	2155	1979	St Vincent	1639
Union Mars	3300	2001	Bahamas	2601
Union Neptune	2376	1985	Barbados	1543
Union Pearl	3774	1990	Isle of Man	2236
Uno	2111	1986	Denmark	1473
Valentin Pikul	2917	1994	Malta	2264
Walter Hamman	1323	1988	Germany	1156
Vangsnes	1738	1985	Gibraltar	1590
Varanger	2630	1975	Norway	1656

VASILIOS N	4958	1978	Georgia	2877
Vasiliy Malov	2557	1978	Russia	1926
Vasiliy Shukshin	2792	1995	Malta	2264
Waterway	1454	1996	St Vincent	1143
Veerseborg	8737	1998	Antigua	6130
Verona	2735	1988	Antigua	2184
VEST	475	1951	Denmark	283
West Carrier	1830	1992	Bahamas	1425
Via	1470	1967	Sweden	1220
Vidi	1970	1968	Sweden	1335
Wilja	2189	1977	Moldova	2068
Willeke	1680	2000	Netherlands	1435
WILSON BAR	6105	1979	Malta	3967
WILSON BRAKE	3710	1997	Malta	2446
Wilson Elbe	2682	1993	Malta	1589
Wilson Tana	7174	1977	Malta	4907
Wilson Tyne	7107	1980	Malta	4913

Vina	2170	1969	Sweden	1303
Windena	2822	1979	Sweden	1770
Windstar	3278	1991	Norway	2237
Vinga	1200	1971	Sweden	1097
Viscount	1558	1976	Panama	1044
VISEU	4672	2008	Madeira (MAR)	2956
Vissersbank	2503	1994	Netherlands	1682
VLIELAND	6000	2005	Netherlands	3990
Volgo-Balt 229	3180	1981	Russia	2516
Volgo-Balt 230	3180	1981	Russia	2516
Volkhov	2085	1978	St Vincent	1639
VOLO	469	1957	Denmark	326
VOORNEDIJK	4450	2009	Netherlands	2984
VYG	2300	1992	Panama	1598
Yuko	1469	1986	Netherlands Antilles	920
Zeeland	1680	2001	Netherlands	1435

References for ship data

Age: Acquired from the webpages: shipspotting and e-ships

DWT: Acquired from the webpages: shipspotting and e-ships

Flag: Acquired from the webpages: shipspotting and e-ships

GT: Acquired from the webpage: shipspotting

Name: Lantmännen historical freight rate data