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Risk Perspective of the Maritime Supply Chain in Norway

An evaluation of the risk perspective in one direct supply chain in the maritime industry in Norway

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Abstract

Norway has a strong maritime cluster and employs 90 000 people. The supply chain in the maritime industry consists of a complex and global network of logistics. The purpose is to collect information about the risk perspective and the way Norwegian companies evaluate risk in the maritime supply chain.

Existing literature has been reviewed and compared to the findings from interviews with high standing personnel in the maritime industry in Norway. Personnel from three companies in one direct supply chain were interviewed to obtain information about the current risk perspective. The risk perspective is continuously changing with the change in market demand and macro environment in the industry.

The companies in one direct supply chain agree that the most significant risk factor influencing their company will vary with time and the macro environment. The companies view of their most significant risk factors in the current conditions is access to raw material, access to human capital, IT security, environmental requirements, on-time delivery, and changes in the production line.

Stricter environmental regulations in the maritime sector are influencing the supply chain to a large degree. The regulatory demands are more present for the companies closest to the end-customer in the supply chain. The risks from the increasing environmental focus are both technological and regulatory driven.

A risk event occurring at one company in the supply chain can cause a ripple effect throughout the supply chain. Close communication upstream and downstream closes the gap between the actors in the supply chain and presents more solutions to reduce the overall impact of risk events.

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1 Introduction

Earth consists of 70 percent of water (ocean, lakes, and rivers). Norway has an extensive coastline regarding its size. Earlier seaborne trade was necessary to move goods to and from the coast of Norway with its remote location from Europe. Now the transportation technology has advanced, and other transport means are in close competition (Association, 2018) (Benito, Berger, De la Forest, & Shum, 2003). Norway has the fifth largest merchant fleet in the world and has an active maritime cluster consisting of ship owners, ship equipment manufacturers, shipyards, ship insurance, and other companies and organizations with maritime-oriented activity. The maritime industry in Norway employs 90 000 people. The industry consists of a complex and global network of logistics (Association, 2018). Globalization has contributed to the increasing transaction of goods over national borders. Shipping of goods by sea is the most environmentally friendly method to move goods over vast distances (Shipyards & Association, 2018). An increase in the environmental and safety requirements are promoting continuous technology development and innovation (Association, 2018).

1.1 Aim of the study

The aim is to create an overview of how the Norwegian actors in the maritime supply chain see and evaluate the risk perspective. The escalation of environmental regulations is influencing the industry to evolve. Technology advances have been rapid in later years, and the environmental focus has impacted the focus areas of the development (Association, 2018).

The purpose of this study is to gather information about risk in the supply chain in the maritime industry in Norway. Personnel from Norwegian companies have been interviewed to answer the research question. It has been decided to give extra attention to how the environmental restrictions are impacting the risk perspective in the supply chain because of the escalation of the environmental regulations in the industry.

Research question What are the Norwegian companies view of the risk perspective in the supply chain in the maritime industry?

The supply chain in the maritime sector is complex. One of the substantial changes in the maritime industry due to environmental restrictions is the change in power generation in ships to lower the pollution of ships. A selection to focus on *one* direct supply chain with one supplier, one manufacturer, and one customer has been done to minimize the complexity of the

thesis (Chen, Sohal, & Prajogo, 2013).

1.2 Structure of the study

This study is built up by seven sections. Section one consists of this introduction. The introduction focuses on the maritime industry in Norway and gives the purpose of the thesis. The next section gives an overview of how the information has been collected. Further on is the section of the theoretical background. The section states relevant background information. Section four gives the result of the information gathered from the interviews to answer the research question. Section five gives an evaluation, and section six states the conclusion of the study. Suggestions for future studies are available in sections seven.

2 Methodology

The purpose of the chapter is to give a general understanding of how the information gathering process has transformed. The information comes from peer-reviewed articles, books, maritime reports, and interviews. The interviews are answered by personnel from the maritime sector in Norway.

2.1 Research Method

A research method is an approach to acquire new knowledge and verify claims. Every means used to collect data can be called a method (Dalland, 2000). To use a method means one uses a predetermined way to collect information (Johannessen, Tufte, & Christoffersen, 2010). There are two main types of methods; qualitative and quantitative. Within the two main method types, there are different approaches to gather information. The methods also focus on different aspects of a phenomenon. There are positive and negative aspects by using both methods, but it is possible to combine the two methods to strengthen the result. If both the methods give approximately the same result, the credibility of the result will be stronger. Information collected by different methods should be analyzed separately. The information collected is split into two categories; primary data and secondary data. Primary data is information gathered directly from interviews and observations in the process. Secondary data is information that already exists from external sources (Dalland, 2000)(Johannessen et al., 2010). The validity of the source explains to which degree the source is valid (Johannessen et al., 2010). A source is of high validity if the information is collected in harmonious relations to the purpose (Dalland, 2000).

2.2 Quantitative Research

Quantitative research is used to gather hard data based on numbers. The approach takes a broad look at a phenomenon. The method gathers a small quantity of information from a large selection of units. The quantitative research method finds the average of the collected information. The data is collected through surveys, existing statistics, and observations. The information gathering process happens without contact with the objects (Dalland, 2000)(Johannessen et al., 2010). A survey has predetermined questions and answers. It is important that the selected units are representative to get liable results. The reliability explains how reliable the information in the study is. It is important to select the wording carefully to avoid misunderstandings and include appropriate alternatives for the answers to ensure the

reliability of the survey,(Dalland, 2000).

2.3 Qualitative Research

The qualitative method is used to create a more in-depth understanding of a phenomenon. The information collected by using the qualitative method is primarily not quantified, and are called soft data (Saldana, 2011)(Noor, 2008). The data collected with this method is from a small group of units, and a large quantity of data is collected from each object. This approach makes it possible to obtain the special of possible deviant information. The method builds on assumptions and in the end, presents the subjects voice (Creswell & Poth, 2017). It is normal to use interviews, group interviews, and/or observations to collect information (Harris, 2015). Qualitative interviews have the purpose of understanding the interview-object point of view. It is important to think through how the information was obtained and processed. With the use of the qualitative method, it can be difficult to retrain the result because of the differentiation in subjects, but also because the information can be interpreted differently by other parties. It is important to select the questions for the research carefully. The questions narrow the focus of the research area and are one of the most important parts of the research (Gelling, 2015).

2.3.1 Case Study

A case study is a part of the qualitative research methodology. The theory is used to explore different concepts which are not widely known and identify relationship from raw data. The research method collects a large quantity of data from a few units. The units are time and location dependent. The case study uses open-ended questions and is asked to subjects (Johannessen et al., 2010).

2.4 Selection of Method

It is important to see the methods up against each other to find the best approach for the selected topic and to understand what is practically feasible. The time limitation for this study is a large reason for the choice to use a qualitative approach. The qualitative method has been used to create a better understanding of the risk in the supply chain for the maritime sector. The secondary data comes from peer review articles, books, and reports from the maritime sector. The companies have been selected due to their relation to one direct supply chain of an equipment manufacturer to the

maritime industry. The interviews represent the primary data in this study and were collected to supplement the secondary data and give a more in-depth understanding of the risk perspective as companies see it today.

The questionnaire used to collect primary data from the maritime sector is build up by predetermined questions with open-ended answers and follow up questions to get a more apprehensive response from the subjects. The questions are build up to answer the research question, which labels this methodology as a deductive approach. The questionnaire consists of the topics; collaboration in the supply chain, globalization, risk factors/risk events in the supply chain and mitigation of those. The primary data comes from the information from the interviews and are used to create a more in-depth understanding of the risk perspective as companies see it today.

The selection of subjects in the interview has been carefully thought through to ensure the reliability of this study. The primary data comes from interviews with managers and executives working in the supply chain and correlating fields within the maritime sector so they can provide meaningful data on multiple arias. The protocol for the interview is available in Appendix A.

3 Theoretical Background

The theory in this section gives background information to support the information collected from the interviews and to give a broader understanding of the risk perspective in the maritime supply chain.

3.1 Risk Management

It is important to evaluate the risk perspective to make well-informed decisions for the future of a company. Risk is defined as an event with uncertainty associated with an outcome. A measure of the probability of the outcomes and the consequence (good and bad) of those outcomes are calculated to evaluate risk. To reduce the risk, it usually means creating barriers to reduce the impact of the risk event (Manuj & Mentzer, 2008) (Aven, 2012). A risk analysis can be used to evaluate the risk perspective. If there is no uncertainty regarding an outcome, there is no risk associated with the decision-making. It is important to evaluate the strength of knowledge the risk evaluation is based (Aven, 2012). When evaluating risk, it is necessary to also include the frequency of outcomes and the speed of a risk event. A low consequence risk with a high frequency can have a large impact on a company. Speed of a risk event can be defined as the rate of delayed discovery of an event or the rate of the discovered failure to the event occurs (Manuj & Mentzer, 2008).

Risk management is a process that is performed to identify potential events that can impact a company and give more security to the decision-making process. Risk is often measured by expected financial losses and time in the supply chain. The purpose of a risk management process is to reduce the occurrence of the risk events and mitigate the impact of the outcome (de Oliveira, Marins, Rocha, & Salomon, 2017). A well-known barrier for the risk event of a fire outbreak is fire alarms and the use of non-flammable materials to reduce the risk of a fire outbreak. The fire alarm helps reduce the time for risk discovery, and the non-flammable materials are reducing the impact of the risk event (Aven, 2012).

A risk analysis is performed to highlight the possible risks associated with a decision and creates a baseline for the decision-making process. The purpose of the risk analysis is to give an overview of what can go wrong/right, why and the consequences of the outcome to make it possible to make a decision related to the uncertainty of the outcome of a decision (Aven, 2012). The risk analysis process consists of three phases:

- 1. Planning** The problem/challenge is defined; project boundaries, information gathering, and organization of the work happen in this phase.

Probability\ Impact	VL	L	M	H	VH
VH	Green	Yellow	Red	Red	Red
H	Green	Yellow	Red	Red	Red
M	Green	Green	Yellow	Red	Red
L	Green	Green	Yellow	Red	Red
VL	Green	Green	Green	Yellow	Red

Source: (Anthony (Tony) Cox Jr, 2008)
Figure 1: Risk matrix

The choice of which risk analysis to use is also established in this phase(Aven, 2012).

2. Risk Evaluation Possible outcomes are identified in this phase, and a consequence analysis is performed for each outcome of creating a risk perspective (Aven, 2012).

3. Risk Treatment The risk perspective of the different outcomes and alternatives are evaluated and compared to each other, and the management makes a decision based on the information from the analysis (Aven, 2012).

3.1.1 Risk Matrix

A risk matrix is a table to measure the severity of risk impacts. The table consists of likelihood or frequency and the impact of the risk events columns and rows with an increasing degree of impact. The analysis uses colors to visualize the criticality of the risk; green, yellow, and red for respectfully low risk, medium risk, and high risk. Figure 1 shows a Standard 5 x 5 Risk Matrix from the Federal Highway Administration (Anthony (Tony) Cox Jr, 2008).

3.2 Supply Chain Management

The supply chain can be defined as sets of entities that are involved in making an end-product/service for the end-customer with the upstream and downstream movement of materials and information between the entities. The

supply chain can be categorized as a direct supply chain, extended supply chain, and an ultimate supply chain. Supply chains are generally a network of enterprises where one company can be part of multiple supply chains (Vallet-Bellmunt, Martínez-Fernández, & Capó-Vicedo, 2011). Every entity contributing to add value for the end-costumer who interacts with the focal company either directly or indirectly are part of the supply chain(Lambert & Cooper, 2000).

The individual company does not compete solely as an entity alone. The collaboration between the entities in the supply chain contributes to competitive advantages for the entities and the supply chain network (Chen et al., 2013). From the closer collaboration within the supply chains, the competition profile in the market has changed, and the supply chains are now competing in a more considerable degree amongst each other (Vallet-Bellmunt et al., 2011) (Lambert & Cooper, 2000).

The concept of supply chain management has been used to explain a multitude of management processes and structures in the supply chain. There are many definitions of supply chain management, and the concept is practiced and understood on different levels (Helou & Caddy, 2006) (Stock & Boyer, 2009). The definitions used to explain supply chain management can be categorized into three categories; a management philosophy, a management process, and the implementation of management philosophy (Stock & Boyer, 2009).

This study will use The Global Supply Chain Forum definition of supply chain management: "Supply Chain Management is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders." (Lambert & Cooper, 2000).

Supply chain management is the coordination of material and information, up- and downstream, in the supply chain to improve the long-term performance of each company and the supply chain as a whole (Vallet-Bellmunt et al., 2011). The coordination of materials in and out of the value chain in a company has gotten increasing attention in later years. To make the flow of material as smooth as possible, many companies have arranged a partnership with suppliers to improve the collaboration between the party's (Mentzer et al., 2001). An entity needs to have a good overview of their vendors to be able to utilize the vendors' capabilities when it comes to efficiency and technical developments (Persson & Virum, 2013).

The globalization of the supply market has forced corporations to become more cost efficient to be able to compete in the global market. Quality is not seen as a competitive advantage anymore, but are expected by the procuring companies. Global supply chains can contribute to compet-

itive advantages such as access to lower cost of labor and raw materials, better financing opportunity, and broader product markets. The globalization of the supply chain also brings challenges for the firms in the form of risk and more considerable uncertainty. Supply chain management requires companies to start focusing on the improvement of the supply chain and not just the individual company in the supply chain (Vallet-Bellmunt et al., 2011)(Manuj & Mentzer, 2008).

3.2.1 Supply Chain Risk Management

The supply chain is more complicated now than it was just ten years ago. Earlier it was a single supply of material moving through the supply chain from supplier to manufacturer and eventually to the end-customer. Now there are multiple paths of supply through the supply chain, a shorter life cycle of products, and increasing demands in the market (Tang & Musa, 2011).

Changes in the economic and environmental environment are increasing the risk in the supply chain (Chen et al., 2013). In 2007 supplier failures were categorized as the number one risk factor from a survey conducted by AMR research (Chen et al., 2013). Markets, reputation, technology, and framework conditions are elements traditionally associated with risk. Climate risk is a relatively new element to the risk perspective. Physical assets and transition to low carbon economy are risk elements that climate risk can be divided into (Shipyards & Association, 2018).

The market has increased in complexity, and customers demand a higher degree of customized solutions. Customization brings a higher degree of uncertainty for the companies in the supply chain. Customization makes it more challenging to plan the internal production and can create disruptions in the supply chain in forms of delayed deliveries and uneven flow in production (Sreedevi & Saranga, 2017). There is often asymmetric information distribution between the companies in the supply chain. The suppliers often do not know the actual demand information while the retailers know the demand information (Chu & Lee, 2006).

3.2.2 Global Supply Chain Risk Management

A global supply chain is more complicated than domestic supply chains and therefore contains more risk. Global interconnection links in an extensive network of companies are prone to breakdowns, macroeconomic, disruptions, bankruptcies, political changes, and disasters leading to higher risks (Manuj & Mentzer, 2008).

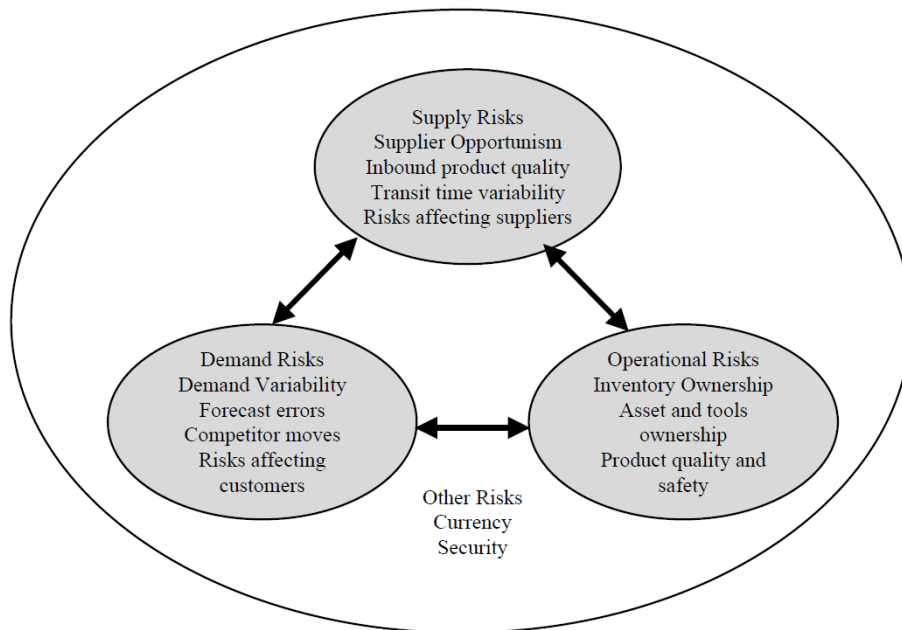
A global supply chain is accumulated with increased lead times, variability in the lead time, physical distance from sources of risk, and less control over the supply chain. The risk associated with the speed of risk events is more extensive in a global supply chain referring to domestic supply chains because of the geographical distance between the source and procuring company (Manuj & Mentzer, 2008).

Risk in a global supply chain, such as the maritime supply chain, can be divided and categorized in multiple ways. This study will use Manuj and Mentzer categorization and are therefore divided into four risk subjects: supply, demand, operational, and security (Manuj & Mentzer, 2008). Figure 2 illustrates the interconnections between risk categorize and risk events. Under the capititation, 'other risk' are risks that are not under the direct control of an entity in the supply chain, where amongst others security is placed. The figure is just an illustration and does not account for every possible outcome. It is essential to understand that a possible outcome for one entity in the supply chain can be a risk event for another entity in the supply chain (Manuj & Mentzer, 2008). The supply risk and demand risk are external risk factors for the focal company, versus operational risk comes from internal risk factors. The supply risk and demand risk are influencing the operational risk (Chen et al., 2013).

Supply Risk Supply risk is associated with the distribution of all possible risk events related to inbound supply, which leads the focal company not to be able to meet the demand in the supply chain/the customer demand. Within this definition are aspects such as delivered at the right time, to the right cost, in the right quantity, and the right quality included (Manuj & Mentzer, 2008) (Chen et al., 2013).

Demand Risk Demand risk is associated with the outbound flow from the focal company and risk events that can impact the likelihood in orders for the focal company, the variance in orders, the volume of orders and any correlation between the subjects which are desired by the customer (Manuj & Mentzer, 2008) (Chen et al., 2013).

Operational Risk Operational risk is associated with the distribution of possible risk events which can affect a companies ability to produce, the quality and the time of production, which again can impact the profitability (Manuj & Mentzer, 2008). It is possible to use manufacturing flexibility to minimize the impact the supply risk and demand risk have at affecting the operational risk (Lloréns, Molina, & Verdú, 2005).



Source: (Manuj & Mentzer, 2008)
 Figure 2: Risk in Global Supply Chain

Security Risk The security risk is associated with the outcomes from risk events that impact the companies integrity, human resources, and information systems. These risk events can lead to outcomes as stolen data, proprietary knowledge, vandalism, sabotage, and freight breach (Manuj & Mentzer, 2008).

The supply chain environment will always contain uncertainty and risk, but the uncertain environment in the supply chain can be reduced. Flexibility in supply and operations can help reduce the risk in those areas (Sreedevi & Saranga, 2017). Collaboration downstream in the supply chain can reduce supply risk, and collaboration upstream can reduce the demand risk. The reduction in supply and demand risk will lead to reduced operational risk. There should be a match on the supply side and demand side in the supply chain. If the balance of supply and demand are mismatched, it will result in either shortages of deliverables or an excess of inventory for the focal company (Chen et al., 2013).

Risk events in the global supply chain can be the currency, quality, safety, forecasts, transit time variability/vulnerability, business disruption, survival, culture, inventory, and ownership of tools, dependency, and opportunism, price fluctuation and risk events affecting other parties in the supply chain.

In a global supply chain, the linkages between risk events are more dominant than in a domestic supply chain and are linked together in intricate patterns. The unpredictability and impact of risk events increase in a global supply chain (Manuj & Mentzer, 2008).

The supply chain in the maritime industry is complex and build up as a matrix of suppliers in an ultimate supply chain. The maritime industry competes on the global market, and the maritime supply chain is global. The pressure to reduce cost has also made the companies in the ultimate supply chains to the maritime industry more global and increased competitiveness (Shipyards & Association, 2018).

3.3 The Maritime Industry

Companies have to continuously develop if they want to become an industry leader in the global market. The maritime market is international oriented, but demand conditions in the national market remain essential. Norway has an extensive maritime cluster. The competition is high between similar companies in close geographical distance. The rivalry amongst the companies remote innovation and development of the companies (Benito et al., 2003).

Technology development in the maritime industry Technology is advancing at rapid speed, which influences the decision-making and strategy in the maritime sector (Association, 2018). Due to the increasing use of digital solutions in ships and the maritime industry as a whole, cybersecurity has gotten increasing attention. The maritime industry is competing globally, but also with rail and road transport. Maritime transport is the most energy effective way of transport (Shipyards & Association, 2018).

The technology of battery solutions in vessels has mostly been used in smaller vessels, but now the technology has started to migrate to larger ships. Heavy fuel vessels will need to install and use Exhaust Gas Cleaning Systems, commonly known as scrubbers, or change to another fuel consumption to operate under the new laws (Shipyards & Association, 2018). Installment of scrubbers in ships who use heavy fuel oil has are the most cost-efficient method to comply with the new environmental regulations for heavy fuel vessels (Van, Ramirez, Rainey, Ristovski, & Brown, 2019).

Environmental regulation of the marine market The increasing focus on global warming and protecting the environment have put the maritime industry under increasing pressure to make the industry more environment-friendly, and the pressure will increase going forward. In the last decades,

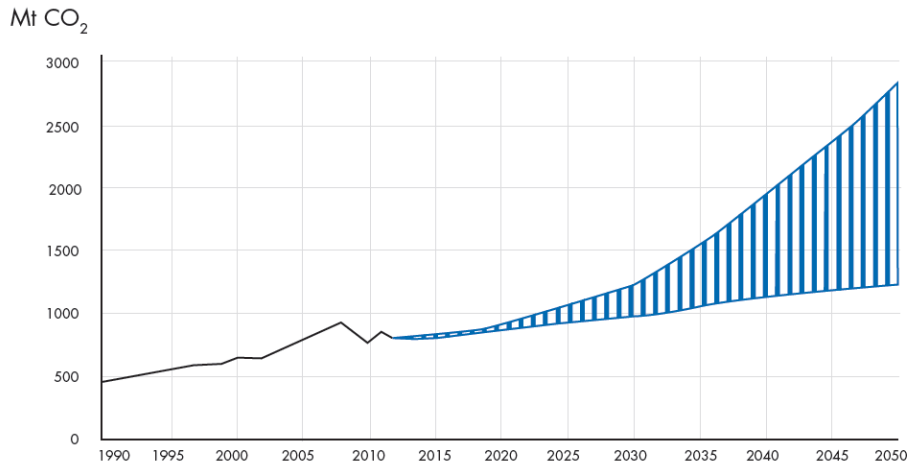
the shipping industry has come under increasing pressure to reduce its environmental impact, and the industry needs to adapt to the stricter regulations (Shipyards & Association, 2018).

Environmental demand leads to a change in power generation and the development of new technology. An increasing amount of new build ships have gone from heavy fuel diesel to gas and hybrid solutions with battery input as power generation to reduce the environmental impact. After cars, ships are most natural to electrify. The environmental status has become commercially relevant for the parties in the maritime supply chain (Association, 2018).

Emission Control International Maritime Organization (IMO) is a branch of the United Nations (UN). IMO issues global regulations on safety, security, and environmental performance on global shipping to limit the negative impact of emission from ships influencing air quality (Van et al., 2019). Ships generate greenhouse gasses (GHG). Emission of sulfur oxides (SO_x), oxides of nitrogen (NO_x), particulate matter (PM) and carbon dioxide (CO₂) are generated from the current fuel used to power ships. The current and future regulations to reduce GHG are expected to become stricter (Shipyards & Association, 2018). The regulations formulated by IMO will have a large impact on ship emissions and development (Van et al., 2019).

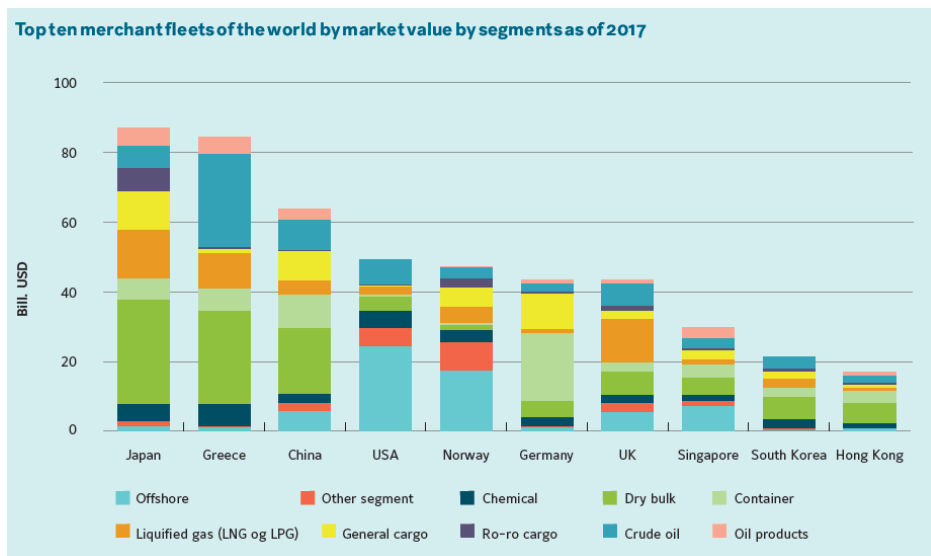
If a carbon-free Europe is to be realized by 2050 as stated in the Paris Agreement, large amounts of renewable power generation needs to be required. The target to reduce emissions with 50 percent by 2050 is a challenge, referring to the numbers from 2008. The shipping industry is also predicted to increase by 60 percent in the same period. There is no current known fuel type or technology that can meet the target for lower ship emission stated in the Paris agreement (Association, 2018) (Van et al., 2019). Figure 3 illustrates the predicted increase of GHG from ships by 50-250 percent from IMO GHG study (Shipyards & Association, 2018).

Slowdown in the offshore segment The oil price slide caused a sensational downturn in the offshore market. The slowdown of the offshore market gravely influenced the rest of the maritime industry. The cause was driven by low oil prices and a high cost of development, which means it was both demand and supply driven. It leads oil companies to cancel and postpone contract for new offshore vessels (Shipyards & Association, 2018). As seen in figure 4, the offshore segment stands for a high percentage of the Norwegian merchant fleet (Association, 2018).



Source: (Shipyards & Association, 2018)

Figure 3: Expected increase in green house gasses from ship emission



Source: (Association, 2018)

Figure 4: Top ten merchant fleets of the world and division of segments

4 Results from the interviews

The results come from the answers from the interviews with maritime actors in Norway from one direct supply chain. The questions used in the interviews are available in Appendix A. One person was interviewed from the supplier side, three persons were interviewed from the operator side, and two persons on the customer side. The number of people interviewed has been chosen based on the size of the companies. The results are divided into the macro environment, which are the risk factors the companies have little or no control over and division of risk factors used in the theory section.

4.1 Macro Environment in the Norwegian Supply Chain

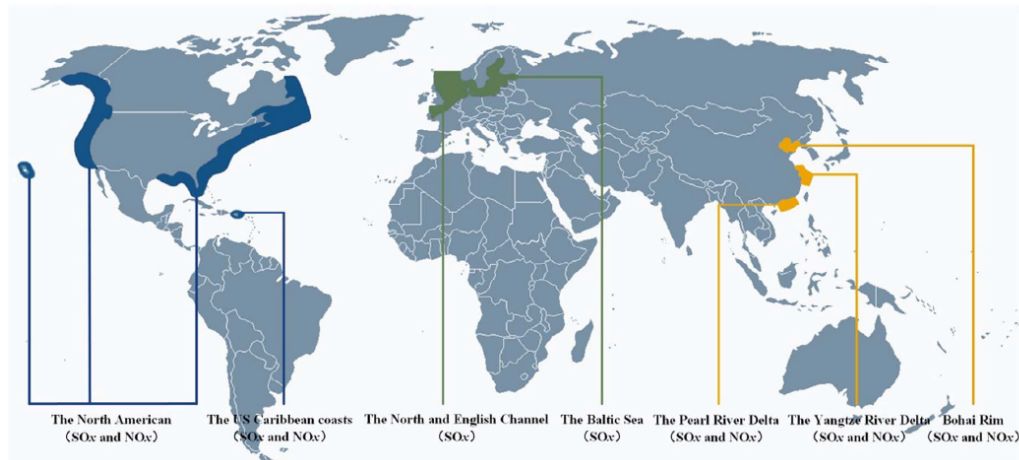
It is crucial for the companies in the maritime industry to understand and evaluate the macro environment influencing the maritime supply chain to understand and predict risk factors and outcomes.

The stricter regulations for emission affect the maritime supply chain, both in the form of change in power generation and the transport/logistic between companies in the supply chain. The environmental regulations and requirements a ship has to be in line with is depending on location and will vary in regions.

Political Factors Emission regulation differs from region to region. Figure 5 shows the regulations for emission control in the different regions. The maritime industry needs to produce an end-product that comply with all of the emission regulation or to the emission regulations where the vessel will operate.

Since the companies are Norwegian registered, the companies have to operate within the Norwegian laws and embargo regulations. Countries listed on Norway's embargo list are countries Norwegian companies are not allowed to trade with. A new country can be added to the embargo regulations as well as being taken off depending on the politics. The Norwegian companies need to place close attention to the political relationship between Norway and other countries to evaluate the risk of other countries being added to Norway's embargo regulation.

Economical Factors When signing new agreements or making new partnerships with suppliers and customers, it is crucial to evaluate the economic stability in the actors' region/country to make sure the supplier will



Source: (Zhen et al., 2018)

Figure 5: Emission control areas

be sustainable, and the customer will be able to fulfill the contract. Fluctuations in currency can also have a significant impact on financial end-result. When companies buy in one currency and sell in another, the fluctuations can be the source of a profit or loss in some cases. The Norwegian currency is also a small currency prone to fluctuations.

Sociocultural Factors Globalization has made international business trades more frequent and increased competition between similar actors. The globalization of the markets gives the Norwegian companies a larger pool of possible suppliers and access to lower cost markets. The business norms will vary from region to region and can differ from the home market. Something which is a standard business transaction in some regions is considered illegal in others. The equipment manufacturer and customer are operating more internationally than the supplier. The companies have their internal code of conduct to ensure they and their business partners work within the appropriate norms and ethics while trading with actors located in other regions. The equipment manufacturer uses a light system to evaluate countries and their risk factors. Countries marked in green can be freely traded with, actors in yellow marked countries need to be carefully evaluated to make sure no laws or ethics regulation are broken and red labeled countries are forbidden to trade with.

Technological Factors New technology can make the management of the supply chain more manageable, but it also brings new risk measures. The upside of technology is the possibility to closely monitor the transport of deliverables and know the exact arrival date the deliverables will be available for the procuring company. New technology also gives the companies a better knowledge of how their products are operating and when maintenance on the products are needed based on measurements and monitoring of the product in action. The downside with new technology is the unknown risk outcomes which can influence the process and cybersecurity. New technology also demands an investment cost and takes time to implement.

Environmental Factors The environmental factors are influencing all three actors. The actors closest to the end-product are influenced at a higher degree, then the actor labeled as the supplier of the companies interviewed. The supplier is not under the direct influence of the shift in power generations and stricter regulations for emission control, but need to make their product more energy efficient. The equipment manufacturer and customer are more affected by the environmental regulations and need to develop products that are in line with the new requirements. The equipment manufacturer has a relative innovating portfolio and can confirm the increasing transaction from diesel to gas generated power solutions.

Legal Factors Since the maritime industry is international oriented, maritime companies have to operate following the laws and regulations present in that region.

4.2 Maritime Supply Chain: Risk Perspective

The macro environment in the maritime industry is changing in phase with the escalation in the environmental restrictions and the technology development in the industry. Supply risk has a high frequency and is dealt with daily. It can be everything from a flat tire on a delivery truck which can lead to late delivery to a supplier bankruptcy.

The companies use a risk matrix to evaluate risk. They use a qualitative approach method to evaluate the risk factors. The risk factors are evaluated by the likelihood and impact of the risk event. The matrix measures increasing likelihood vertically and increasing impact horizontally. The risk factors

on the top right corner in the matrix are labeled as high-risk factors and are visualized in red. The bottom left corner is labeled as low-risk factors and visualized in green. No risk factors are allowed to be categorized as red without measures to mitigate the risk.

Supply The actors' interview identified high-risk components as parts procured from monopoly, duopoly, and oligopoly vendors and parts with a high influence on the success of the finished product. The companies are using a bid strategy for most of the parts above partnerships. For the critical parts, partnerships are used to a higher degree.

1. Shortage/delay of supply Close communication is used to mitigate supply risk. If there is a shortage in supply which cannot be mitigated internally or with the help from the vendors, communications with customers can help mitigate the outcome of the risk event. Some projects cannot be delayed. In other projects, there are delays from other parts of the supply chain, which makes a delay more acceptable/tolerable. Projects also have different critical levels. The communication lines with customers lead to a conclusion if other projects with a lower critical status can get extended delivery time in order to get a more critical project delivered on time.

2. Single Source The risk of a single source of supply was mentioned by each actor in the direct supply chain interviewed. The parts which have a high impact on the finished product can only be available from a few available suppliers. The competitors are also procuring a multitude of critical/high-risk parts from the same vendors. It is critical to have a good forecast and agreements to secure capacity at the step below in the supply chain. The supplier to the equipment manufacturer uses closed collaboration and loyalty to one single source of supply as a strategy with its supplier. The supplier does not always give the lowest prices on deliverables, but when there is a high demand in the market, the partnership gives the actor a priority in line of supply.

3. Capacity at vendors and implementation of new vendors The demand in the market is increasing at a rapid speed. A risk factor followed by the development in the market is the production capacity at the vendors. Ongoing evaluation of the vendors' capacity and potential new suppliers to reduce risk related to capacity and the risk of implementing new vendors.

To get a new vendor to deliver deliverables are a closely monitored process to account for the risk factors, a new source of supply brings. The implementation of a new supplier can also bring more financial risk in the form of the need for new fixtures and tooling for the deliverables. The implementation of new vendors to the supply chain consists of multiple phases. It starts with benchmarking of multiple suppliers to then filter out the ones the company wants to get a closer knowledge about based on the evaluation criteria from the benchmarking. The potential vendors need to be closely evaluated to make sure they can satisfy the standards needed. Audits and trial orders are performed to make sure the companies can deliver as promised. The automotive industry is more developed than the maritime industry. If a supplier is delivering to the automotive industry, the supplier is already working to strict quality requirements and the maritime industry can use that as an indicator if they do not have time to fully train the supplier before implementation or to speed up the implementation time.

Demand The demand risk is highly associated with environmental factors in the industry.

1. The slowdown in the offshore segment The companies interviewed in the direct supply chain were also highly impacted by the change in demand from the offshore segment under the oil crisis. To reduce the risk impact of similar events, the companies have differentiated their portfolio to contain more balance between the different segments in the portfolio.

2. Fluctuations in the market The maritime market is known for continues fluctuation. To mitigate the risk of fluctuations the actors are operating in multiple markets and segments across customer groups, countries and regions to keep a balanced portfolio and balance the size of the customer to make sure the customer does not grow too large.

3. Environmental regulation The environmental regulations are believed to become more strict in the future years. The equipment manufacturer is delivering products that take 3-5 years to develop. To develop new products which are in line with environmental requirements takes time. Therefore it is necessary to start developing and planning for future regulations and requirements before they are active. It is imperative that the actors in the maritime supply chain can readjust their products to comply with the

environmental regulations when they are regulated. The macro environment needs to be closely monitored to pick up on changes in the environment of the supply chain.

Operational There were four risk factors on the operational side which were given extra attention in the interview by the interview objects; production in a high-cost country, Norway's remote location, available personnel, and customization of products.

1. Production in a high-cost country The labor cost in Norway is high. The Norwegian companies invest in automation of their production to close the competitive advantages the low-cost countries have on pricing. Norway is in a large degree operating machines with small modifications from human operators or have one operator operate multiple machines in the same period to lower the cost and up their production efficiencies.

2. Norway's location Norway has a remote location in Europe. Its location can course challenges with lead times from international sources because of the distance. Since the industry is global, Europe is closer located compared to Asia, which is a growing market in the industry.

3. Available personnel The maritime industry in Norway is experiencing increased activity after the slowdown in the offshore sector. The change of activity comes at the same time as other segments in the Norwegian market are increasing its activity. The increasing need for personnel in the industry are closely related to the activity level in the industry and the technology development to ensure qualified personnel for the tasks within a company.

4. Customization The companies interviewed deliver a customized product, which means the products will be slightly different on all orders. The customization of the products leads to risk in the form of the product are still being designed when the production starts. This can result in delays in production and delays to the customer. Considering all products are customized, the company is relying on vendors who can quickly turn around to produce the parts in time for the need date. Closely located suppliers have

the benefit of shorter transport time when the need for a quickly made part is urgent. The customization is mostly influencing the companies close to the end-customer in the supply chain. The vendors who are making a version of the customized part (a part of the product family) can have an advantage with a familiarity of the design. The implementation of new designs is often underestimated in the form of time and resources.

Security Security regulations are maintained at a cooperate level or out-sourced amongst the analyzed companies. With the continuous development of technology and a wider range of online systems, the IT security of the companies is in high focus. Each actor has put in place security measures to prevent and mitigate security risk. The operators in the supply chain are trained and informed about security risks and regulations to ensure the integrity of the companies and the security of its personnel. The external security threats are continuously being monitored to prevent security breaches. Since the maritime industry is technology driven and has technology property, backup-systems are used as a barrier to prevent loss of data. To prevent technology property rights and patents to become know to the public and their competitors, both the employees and vendors have to sign nondisclosure agreements.

The equipment manufacturer has divided the responsibility to make the demand, source the demanded deliverables, and buy the deliverables between three positions to prevent corruption.

4.3 Most Significant Risk Factors from the Results

The companies agree that the most significant risk factor influencing their company will vary with time and the macro environment. The companies view of their most significant risk factors is access to raw material, access to human capital, IT security, environmental requirements, on-time delivery, and changes in the production line. When the market demand is increasing; access to raw material, on-time delivery, and access to human capital regarding growth are in high focus. The change in the macro environment and technological advances leads to the increased risk factors of data security. The companies are dependent on big technical data and property rights. The environmental demand and technological advances lead the companies to adapt their products to fit the environmental regulations in the industry and further develop their products. The industry is also strongly influenced

by the customers' power and is making customized products. The companies ability to manage change without mistakes and under high pressure to account for these constant changes in the production are a significant risk factor.

5 Evaluation and Analysis of the Results

In this section, the results from the previous section are evaluated and combined with the information from the theoretical background. The risk perspective in the maritime industry is changing with the macro environment. The severity of the risk factors varies with time, trends in the market, and the macro environment. The market is currently facing increasing demand and higher volumes of orders.

Risk factors dependent on the market demand The maritime industry is known for fluctuations in the market. Below are the risk factors which are dependent on the market demand.

Downturn in a segment The companies have put more focus on their product portfolio after the downturn of the oil segment to have more security of survival after the effect the downturn had on the companies interviewed. A balanced portfolio will give the companies multiple segments and markets to keep their production and sales up when one segment collapse. It is the norm to change from external to internal production when the demand in the market gets low to be able to keep personnel and the production going. The change gives a more considerable loss for suppliers of those deliverables in the form of lower quantities and a smaller portfolio. With the challenges in a downslope market, the risk for bankruptcy increases because of less demand in the market and higher competition. When companies have the available capacity, they lower the prices to attract more work to make an income. Long term service agreements on deliverables are one way to ensure income to a company and the supply chain with fluctuates and a downslope in the market.

Upturn in the markets Delay of supply will have a higher impact on the companies when the market is in an upturn because of the higher production rate and a more significant need for deliverables. The higher production rate can lead to capacity challenges for both the procuring company and the suppliers. It is normal to outsource parts that have been made internally to ease the internal capacity challenges. The change puts extra pressure on the current vendors in the form of capacity. The suppliers will get an increasing quantity of the current parts, among new parts. The capacity challenges can lead to increased lead times and quality discrepancies to be able to support the extra workload. New vendors are needed to reduce capacity challenges. To integrate new suppliers into the supply chain creates new risk elements.

The integration is time-consuming and can take years. When the capacity challenges get to large in a short amount of time, the need for new suppliers can be quicker than the standard implementation time. The need for a shorter implementation time can cause the standard implementation process to be cut down, and risk factors not be as strictly evaluated. A single source of supply contains more risk in a market with increasing demand. The capacity of a single source can be influenced when the demand is increasing. Fluctuations in demand create a large room for unknown risks. The increasing demand in the market also increases the need for human capital, and companies can need additional personnel to cope with the higher quantities of deliverables. Globalization and technology advances have made it easier to obtain human capital. The workforce is no longer fixed to one geographical location.

Norwegian based operation Norway's remote location from Europe cannot be changed, but when the lead time is pressured, as in a high demand market the need for shorter lead time occurs more frequently than in a stable or sinking market demand. Globalization and innovating transport technology have made the distribution of goods between regions smaller and lowered the risk of distribution between the source of supply and procuring companies from different regions. The Norwegian companies use technological development and organization of human capital to reduce the competitive advantage sources from low-cost countries obtain on the international market. The interviewed actors operate with relative small batch sizes. Low-cost sources regularly have a higher cost benefit with serial production compared to sources in Norway.

Stricter environmental regulations The stricter environmental regulation causes the end-customer to put increasing pressure downstream in the supply chain to develop new solutions. It is time and resource consuming to develop new products and modify deliverables in the maritime industry. The end-customer is again pressured by legislation and politics to comply with current and future regulations. The regulations for emission control are predicted to become stricter and considering there is no current power solution available to comply with the target set in the Paris Agreement the possibility intensifies. The challenges and changes in the maritime industry are both technological and regulatory driven in this aspect. Technology is evolving at a rapid speed, and new and more innovating solutions are made available. The influx of new and more suitable solutions are shortening the life cycle of the current technological solutions which make continuous learn-

ing and adapting necessary. If a company can provide a proof of concept for innovating deliverables operating on a higher level than the regulations requires, the actor can influence the regulations to become stricter by proving the technology exists and get a head start compared to their competition.

Flexibility of production and communication in the supply chain

Flexibility in production can help reduce the impact of supply and operational risk. The supply risks have a high frequency with the equipment manufacturer. A dual source of supply will ensure better flexibility in supply, and if one source is suffering from, for example, a break down in machinery, the procuring company has an alternative source of supply to compensate. A single source can be a strategic decision, but a single-source contains more risk than a dual-source. A smaller quantity of suppliers is easier to manage and creates more time and resources for the development of strategic vendors. The vendors' capabilities can be utilized to create value for both the supplier and the procuring company. Knowledge transfer between companies in the supply chain can help develop more efficient and innovative solutions.

When one company in the supply chain is dealing with a risk event, other actors in the supply chain can be affected. The example above states the risk event of a break down of machinery. The risk event has happened to one actor in the supply chain, but the outcome is creating a ripple effect upstream in the supply chain if the actor does not have barriers in place to reduce the external impact. Communication and partnerships downstream and upstream in the supply chain will help mitigate the risk of a ripple effect in the supply chain from a risk event.

6 Conclusion and Observations

The competition in the maritime market is high. Companies are faced with increasing pressure to reduce costs, minimizing the environmental impact, and improve customer service. The companies strong need to reduce their internal cost can affect the overall optimization of the supply chain.

The changing environment in the maritime industry is influencing the risk perspective in the supply chain. The companies close location to the end-customer in the supply chain is more affected by the environmental regulations in the industry. Innovative solutions are needed in the maritime industry to be able to meet the emission target set by the Paris Agreement, and the regulations set by IMO are continually becoming stricter. The technological and regulatory demands are affecting multiple actors in the supply chain and a collaboration between the actors in the supply chain is needed to find satisfactory solutions to meet the target and comply with future regulations. Companies that are at the forefront of developing new solutions get a competitive advantage and can contribute to shaping the regulations by proving the technology exists.

By understanding the variety and interconnecting linkages between the risk events in the global supply chain, companies can tailor risk strategies that balance and effectively reduce the risk factors or lower the impact of the consequences. Close communication and collaboration have been identified as the most significant contributor to reducing the impact of risk outcomes in the maritime supply chain. When a risk event in the maritime supply chain has occurred, the impact of the outcome can be reduced through close communication downstream and upstream in the supply chain. Close communication closes the gap between the actors in the supply chain and presents more solutions to reduce the overall impact. When one actor is experiencing an impact from a risk event, other companies in the supply chain can be affected by a ripple effect from the risk event, and it is in the supply chains' best interest to work together to minimize the impact of the outcome for the whole supply chain.

A flexibility manufacturing plan can help reduce the impact in the production of the focal company from supply risk. The supply and demand paths in the supply chain need to match. An uneven correlation between supply and demand will respectively lead to a shortage of supply or a stock build-up, which will impact the operational risk for the company.

7 Suggestions for Future Studies

This study has evaluated the risk perspective in an upturn market for one direct supply chain in the maritime sector in Norway. Several research areas can be considered for future progress from the information in this study. The first step is to expand the research units from one direct supply chain to multiple direct or extended supply chain to create a better overview of the risk profile in the maritime supply chain in Norway and other regions. Considering the maritime supply chain is global, other nationalities are contributing to add value for the end-customer.

The maritime industry is set up as an ultimate supply chain with a web of actors operating to create value for the end-customer. The expansion of the research area to include the ultimate supply chain will present a more realistic insight into the risk profile in the maritime industry. The linkages between risk events in global supply chains are more dominant than in the national supply chains.

It is clear that the macro environment is affecting risk perspective and are influencing the companies decision-making. Another aspect of future study is to which degree the macro environment is influencing the risk perspective for global supply chains and how the risk perspective is changing in different demand settings.

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A Appendix: Interview questions

Introduction:

- Interviewer
- Subject: Background, position, organization structure, company type
- Confidentiality and permission to audiotape

Company position from the interviewed companies

- Supplier, manufacturer, and customer

Questions:

1. What is your view of the collaboration in the maritime supply chain?
2. Please mention some of the risk factors which have influenced the supply chain in your company/work?
3. How are the environmental requirements impacting the maritime sector in your view?
4. How do advancing technology development impact the risk perspective for the supply chain in the maritime sector?
5. What are the risks you are facing on the customer/demand side and how were those tackled and mitigated?
6. What are the risks you are facing on the vendor/supply side and how were those tackled and mitigated?
7. What are the risks you are facing on the operational side and how were those tackled and mitigated?
8. What are the security risks the company is facing and how are those mitigated?
9. How does globalization influence your/the company's risk profile? For example, destabilization of markets, competition, fluctuations, global rules, embargo, a different view of code of conduct, etc.
10. Are you/the company using specific strategies or measures to mitigate risk?
11. What imposes the largest risk factor in your company?

12. How do you/the company capture and work with supply chain risks?
13. Please share some risk incidents from your experience.

Follow up questions to get more detailed answers:

1. Explain that in more detailed
2. Can you give examples?