Master's degree thesis

LOG950 Logistics

Engineer-To-Order and its Competitive Advantages: A Case Study of the Norwegian Maritime Equipment Suppliers

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Preface

This thesis has been conducted during spring 2020 as the final part of our Master of Science in Logistics at Molde University College. Throughout this thesis, we have benefited by receiving crucial information from companies within the research field. Our data gathering was weakened due to the situation with Covid-19 which occurred in March and consequently shut down activity in Norway. The companies declined further access, thus, it was difficult for us to get more respondents to interview and answer the survey. However, thank you to all participants for taking their time for both interview and survey.

We would also like to thank our supervisor Steinar Kristoffersen and our co-supervisor Kristina Kjersem for all advice and guidance throughout this process. We are thankful for the constructive criticism and helpful discussions that have motivated us this last semester. Furthermore, thank you for helping us reach out to relevant respondents for our research.

Last but not least, we want to appreciate our families, friends, and fellow students for words of encouragement. Thank you to all involved, helping us achieve this final product that we are proud of.

Molde, 29.05.2020
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Abstract

The aim of this thesis is twofold. First, it looks at how ETO influences the supply chains of the maritime equipment suppliers. Second, it assesses if ETO is a competitive advantage. Norwegian equipment suppliers are known for a high degree of quality and a high level of expertise that enables the development and building of highly customized equipment with an ETO approach. Research has been conducted concerning shipyards, ETO, concurrent engineering, uncertainty in projects, coordination, communication, standardization, and modularity. However, we found that there was limited research on these areas when it comes to Norwegian maritime equipment suppliers. Therefore, this thesis research analyzes how these factors affect the maritime equipment suppliers and how customer involvement is affecting the processes in the project.

Our key results emphasize that the companies should consider finishing early phases, like design, drawing and technical details before engineering and purchasing. However, the purpose is not to eliminate concurrent engineering, it is to reduce uncertainty and need for rework. The customers and suppliers should be involved early at the design phase to avoid big changes later in the project, and to have successful concurrent engineering. Ensuring good communication and coordination with involved parts are crucial to ensure a successful project, especially if the companies offshore or outsource production. Tailored customization, where design is re-used and adjusted based on customer requirements, could help reduce lead-time and cost on the design and engineering work. Modularity trough component-sharing and cut-to-fit allows the customer to design uniquely the product around a base unit of components and allows unique dimensions to the product. Further, modular options will allow reduced lead-time and cost while simultaneously maintain a great variety of products. Lastly, customer decoupling points are dependent on the number of changes from the customer, a large portion of the companies involved in the study allows changes throughout the project.

Key words: ETO, maritime equipment suppliers, standardization, modularization, project changes and outsourcing.

Table of contents

List of Tables

List of Figures

List of abbreviations and acronyms

ATO	Assembly-To-Order
CE	Concurrent Engineering
CADP	Customer Adaptation Decoupling Point
CODP	Customer Order Decoupling Point
DP	Decoupling Point
ECs	Engineering Changes
ETO	Engineer-To-Order
EW	Early Warning Signs
IDP	Information Decoupling Point
MTO	Make-To-Order
MTS	Make-To-Stock
OP	Order Penetration

1.0 Introduction

The Norwegian shipbuilding industry is known for its quality and expertise that enables development and building of highly customized vessels with an Engineer-To-Order approach. Most Norwegian shipbuilding companies operate in a global market and compete with companies that are able to produce at a lower cost (Jakobsen et al., 2019). For offshore vessels, China has become a major competitive actor known for delivering low-cost standardized products. Norwegian companies have a high labour cost, and to be competitive they have had to focus on other characteristics of their products besides price. After the financial crisis in 2008 and the low oil price in 2014, the shipbuilding industry has been forced to look at new market opportunities as the investments from offshore oil and gas have been limited (Jakobsen et al., 2019).

Vessels and maritime installations are dependent on equipment produced to cope with the demanding marine environment. Maritime equipment suppliers are both developing and delivering equipment to shipyards, offshore oil and gas industry, fishing industry, and other maritime operations (Helseth, Mellbye and Jakobsen, 2018). The Norwegian maritime equipment suppliers use an Engineer-To-Order approach to adapt their products to the specific customer specifications.

Engineer-To-Order (ETO) supply chains produce in low volumes a high variety of products that allow customers to demand products that are developed to satisfy their needs (Mello, Strandhagen and Alfnes, 2015a). According to van Weele (2018), there is no stock within an ETO supply chain. As a result, the entire project is based on specific customer orders. The process in an ETO supply chain starts at the engineering phase and the products are designed and engineered in close collaboration with each specific customer (Rushton, Croucher and Baker, 2017).

As mentioned, the Norwegian maritime equipment suppliers use an ETO approach when developing their products. Suppliers in other countries often develop products that are more standardized. In accordance with previous research, we found it interesting to investigate if ETO is a competitive advantage for our case companies and how the Norwegian maritime equipment suppliers look at an increased level of standardization. This is elaborated more in the following section.

1.1 Relevance of the study

This thesis investigates the Norwegian maritime equipment suppliers that have an ETO supply chain. These suppliers use a large degree of their resources on engineering activities for products that are being produced in a more standardized fashion in other countries. The aim of our research is to find if ETO is a competitive advantage for the Norwegian maritime equipment suppliers, as engineering is a large consumer of lead-time. We also seek to examine if the maritime equipment suppliers could benefit from more standardization and modularization. Further, a discussion will follow on how concurrent engineering, product changes, customer involvement, communication, and place of production make these projects more complicated than needed.

Previous research is conducted within the fields mentioned above. Vaggen, Kaut and Wallace (2017) have studied the impact of design uncertainty when planning ETO projects. They explain that while flexibility for the customer is good, it also represents a source of uncertainty for the producer. This could lead to continuous adjustments in purchasing, engineering, and execution. Mello, Strandhagen and Alfnes (2015a) have studied how coordination plays a role in avoiding project delays in an ETO supply chain. They explain that a high level of concurrency is necessary in order to reduce project lifetime. However, more concurrency increases the interdependencies between activities, something that demands more coordination, and could potentially lead to the appearance of several problems causing rework and delays that increase lead-time. Mello, Strandhagen and Alfnes (2015a), Novak and Eppinger (2001), Ulrich and Eppinger (2000), and Ettlie (1997) suggest that the need for coordination can be reduced by adopting more standard components, modular systems, and production-friendly design. Further, Mello, Strandhagen and Alfnes (2015a) state that the application of such approaches is limited in the Engineer-To-Order supply chains due to customer involvement in product design. Therefore, this thesis aims to research the possibility to increase the use of standard components and modular systems.

There is a research gap when it comes to decoupling points in ETO production systems. It is stated in Semini et al. (2014) that there seems to be a lack of research analysing Customer Order Decoupling Point and strategies for the production of low-volume customized products. The article written by Semini et al. (2014) is based on the study of a ship designer and yard with experience in producing offshore ships using a customized design approach. They further state that there is a need for additional case studies and surveys to validate

findings. This is to secure a better understanding of how the shipbuilding industry relates and adapts both processes and strategies to its markets. In the section for further research they suggest conducting research on Customer Order Decoupling Point in more standardized segments.

To our knowledge, there is little previous research about Customer Order Decoupling Point and its influence on Norwegian maritime equipment suppliers. However, several research articles involving ship designers and shipyards were found. Anumba and Evbuomwan (1997), Pieroni and Naveiro (2006), Semini et al. (2014), Mello (2015), Haji-Kazemi et al. (2015) have all conducted research involving the shipbuilding industry. Several similarities can be seen between shipyards and maritime equipment suppliers. Based on the preliminary findings it may be easier for maritime equipment suppliers to have a higher degree of standardization and modularization as they produce one specific product using high internal expertise.

Through this thesis, a multiple case study of different maritime equipment suppliers that deliver their product to shipyards, offshore industry, fishing industry, and/or other maritime operations have been performed. The preliminary findings suggest that standardization and modularization were practiced by some companies, and in the literature, it is seen as a possibility to decrease lead-time and cost. Therefore, it is interesting to investigate how companies operate today. If they see a possibility to standardize more, and whether ETO is a competitive advantage or not. In addition, several of the companies had outsourced or offshored their production to other low-cost countries. Hence, it would be interesting to take a closer look at how communication and coordination for these companies where affected. This leads to the following research problem.

1.2 Research problem

The primary purpose of this thesis is to examine how an ETO supply chain affects the maritime equipment suppliers.

> *How is the ETO production strategy influencing the supply chain, and is ETO a competitive advantage for the equipment suppliers in the maritime industry?*

In order to be able to answer this research problem, two research questions have been formulated to come to grips of the factors that could influence a supply chain. The aim of the first research question is to highlight factors that could affect the ETO supply chain for maritime equipment suppliers. The second research question aims to research how customer involvement affects the processes within the projects.

RQ 1: Which factors affect an ETO supply chain for maritime equipment suppliers?
RQ 2: How is customer involvement affecting the processes in the project?

1.3 Structure of the thesis

This thesis is structured into six main chapters with several relevant subchapters. The six main chapters are the introduction, theory, methodology, case description and findings, analysis and discussion, and lastly, the conclusion. In *chapter 1*, the introduction, the background and the motivation for this thesis are presented. The research problem and associated research questions are introduced, along with a brief overview of the literary basis.

In *chapter 2* the theoretical framework is presented and provides the literary basis of the thesis. The main theory is about Customer Order Decoupling Point and ETO. Within these main theories, the chapter elaborate the terms concurrent engineering, standardization, modularization, engineering changes, project management, offshoring and outsourcing, and communication and coordination. *Chapter 3* outlines the methodology, research design and data collection methods for the thesis in order to illustrate the process of answering the research question.

Further, the case description and findings are presented in *chapter 4*. This chapter is twofold, first comes a presentation of the Norwegian maritime equipment suppliers, while the second part shows our findings from the interviews and survey. *Chapter 5* present the thesis´ analysis and discussion of the main findings by answering the two research questions. Lastly, the conclusion in *chapter 6* will answer the research problem.

2.0 Theoretical framework

This chapter presents the literature that is relevant for this thesis. It explain decoupling point and where it is placed in the different production strategies focusing on ETO, its characteristics, and different types of ETO. Thereafter, several strategies are being explained to improve an ETO supply chain with concurrent engineering, standardization and modularization. Lastly, other factors that impact an ETO supply chain are elaborated, such as outsourcing, offshoring, communication and coordination.

2.1 Customer Order Decoupling Point

Decoupling points (DP) have a crucial role in production and logistics (Wikner, 2014). Shahin et al. (2016) state that DP can have an important impact on the dynamic performance of a supply chain, reduce cost, and increase profitability. Therefore, a strategic placement of the DP is important.

The most common word used for DP found in the literature is Customer Order Decoupling Point (CODP). According to Olhager (2010), the CODP is the point in the supply chain for a product, where the product is linked to a specific customer order. Semini et al. (2014) describe DP as the place where a customer order-based supply chain is separated from the part that is based on forecast and speculations. Several articles (Gosling, Hewlett and Naim, 2017; Wikner, 2014; Cannas et al., 2019) mention Sharman (1984) as the first source that described DP. Sharman (1984) defines it as the order penetration point (OP) and argues that the supply chain is driven by customer orders the more downstream the OP is placed. Upstream, forecast and plans are the drivers for the supply chain.

The traditional DP focuses mainly on the material flow in the supply chain and the flow of information is not considered. Mason-Jones and Towill (1999) argue that in order to maximize performance and improvement, one should also consider the Information Decoupling Point (IDP) which is the point in the supply chain where marketplace order data enters without modification, as an invitation for tendering. At this point, the market driven and forecast driven information flows meet and becomes information about actual demand (Mason-Jones and Towill, 1999). Further, Mason-Jones and Towill (1999) state that the IDP needs to be positioned as far upstream as possible in order to maximize performance in contrast to the CODP which is placed as close to the end customer as possible.

Olhager (2010) and Sharman (1984) describe the CODP as the point where product specifications get frozen and the last point at which inventory is held. Wikner (2014) criticizes DP as too simplistic in some cases and that it represents a "black or white" scenario. Hence, he represents "shades of grey" which is a hybrid decision domain that he describes as a decoupling zone. Wikner (2014) goes on to describe that "a decoupling zone covers decisions that are made under mixed properties related to one or more decision criteria".

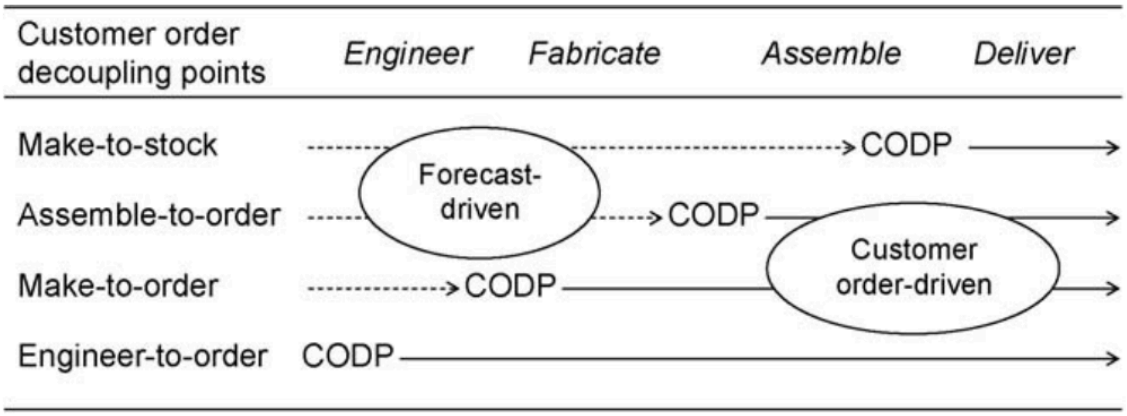

Figure 1: Different Customer Order Decoupling Points (Source: Olhager, 2010)

As we can see from the figure above, there are different production strategies with different placement of CODP, this will be further explained later. The material flow can be divided into forecast driven and customer order driven. A downstream shift in the CODP implies that the supply chain is more forecast driven, and this could shorten lead-times, increase reliability, and lower cost (Semini et al., 2014). On the other hand, an upstream shift in the CODP means that the supply chain is more customer driven, which enables a higher degree of customization. It will also reduce reliance on forecasts and inventories decreases along with inventory costs (Semini et al., 2014).

Shahin et al. (2016) argue that CODP is a divider between lean and agile supply chains. Lean supply chains focus on reducing waste and utilizing resources, being more productive. Conversely, the most important criteria for agile supply chains are speed and capability to respond quickly to demand, and therefore being the most flexible (Shahin et al., 2016).

2.1.1 Customer Adaptation Decoupling Point

According to Wikner and Bäckstrand (2017), CODP does not take customer requirements into consideration. The Customer Adaptation Decoupling Point (CADP) is where a unique process or product is adapted for a specific customer order (Wikner, 2014).

"The customer adaptation decoupling point (CADP) separates decisions about differentiating flow based on standardization for a market of different customers from adaptation against actual customer orders" (Wikner, 2014, p 196).

Furthermore, Wikner (2014) describes the processes upstream from the CADP more generic and can provide standard products, while downstream the process is linked to a specific customer order to enable customization. Hence, the CADP represents the interface between the flow of standard products and customer order adapted products (Wikner, 2014).

2.1.2 CODP and production strategies

The position of the CODP can be connected to different production strategies, such as Make-To-Stock (MTS), Assemble-To-Order (ATO), Make-To-Order (MTO) and ETO. On the one hand, it can be argued that the production strategies that are forecast driven, MTS and ATO, have a push strategy. On the other hand, it can also be argued that MTO and ETO have a pull strategy. The point where pull and push meet is the location of the DP (Calle et al., 2016). In these production strategies, the position of the DP will vary. The placement of CODP is about finding the equilibrium between flexibility and efficiency (Cannas et al., 2019). The following figures 2, 3, 4, and 5 shows different production strategies from product development to delivery and customer involvement.

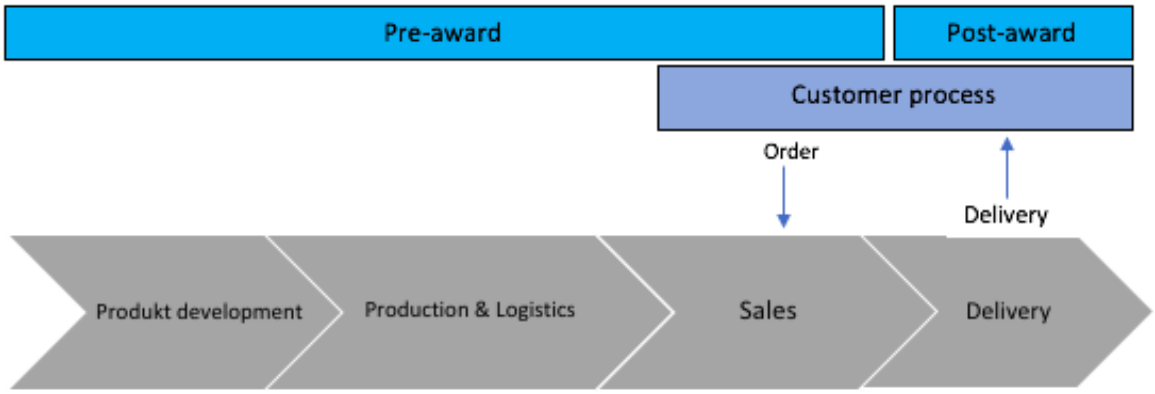

Figure 2: Make-To-Stock (Source: Inspired by Willner et al., 2014)

In figure 2 were MTS is presented, we can see that most of the activities are done before the customer gets involved. The product is developed, produced, and stocked before a customer order is present. The CODP is placed late in the process and the customer buys products from stock. Such products are standardized and produced in high volumes, and the pattern for demand is relatively known (Mello, 2015).

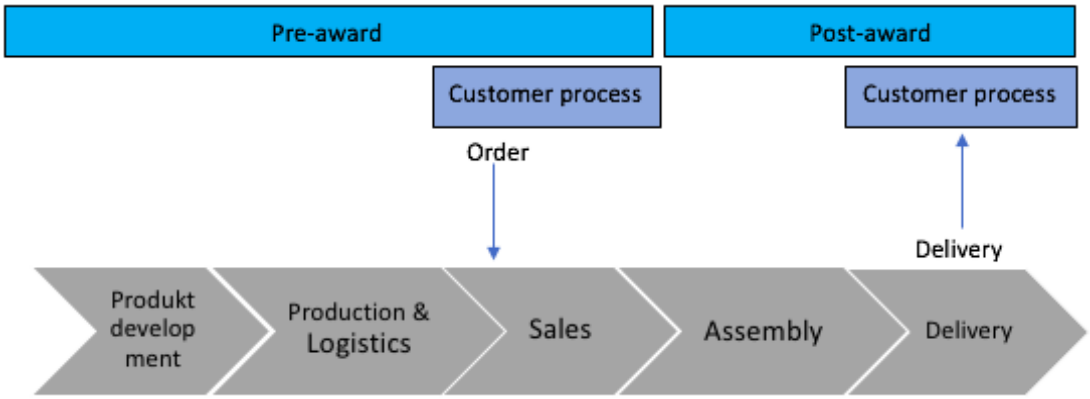

Figure 3: Assembly-To-Order (Source: Inspired by Willner et al.,2014)

In ATO production strategy the customer has a limited number of product variants available (Mello, 2015). The customer comes into the process after the product development and production. However, the product is not assembled until after the order is placed. After the product is assembled, it is delivered to the customer. Most of the standard components for the product are usually in stock, and according to Mello (2015), standard components are supplied and produced efficiently in batch sizes to be assembled into the final product using a modular approach. Mello (2015) further argues that it is important with efficient production and logistics processes to achieve low cost and fast delivery.

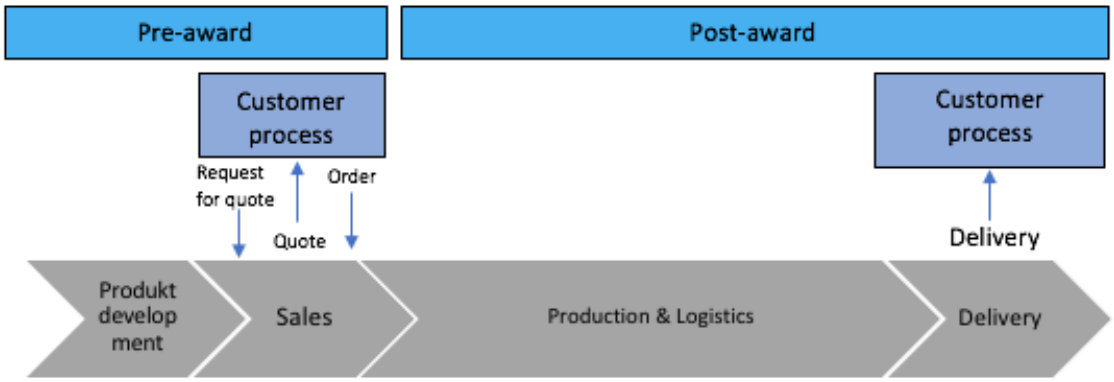

Figure 4: Make-To-Order (Source: Inspired by Willner et al., 2014)

In an MTO production strategy, product development is usually not connected to a specific customer order, it is rather based on market forecast (Willner et al., 2014). As shown in figure 4, the sales phase starts with a request for quotation from the customer, while the production starts after a purchase order is registered. Even though the product has been designed in advance, parts of the product are customized to meet the individual customers´ needs. Mello (2015) mentions that a combination of modular and customized components provides great flexibility to meet individual requirements in this production strategy.

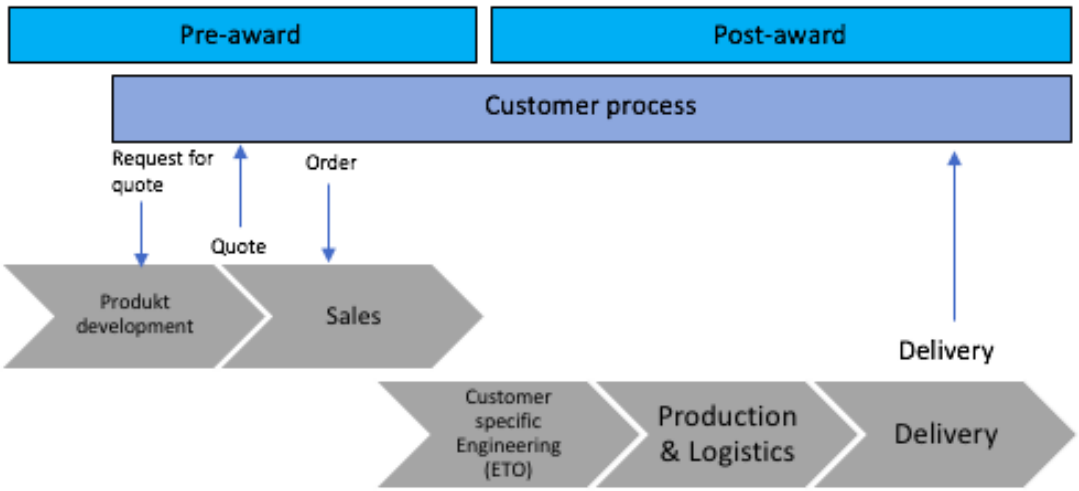

Figure 5: Engineer-To-Order (Source: Inspired by Willner et al., 2014)

In figure 5, we see the production strategy ETO. The customer is early involved in the process of designing and developing the product. None of the specific production activities have started before a specific customer order is confirmed. In the phase *customer specific engineering* the design activities for a specific customer order are carried out (Willner et al., 2014). It can be small adjustments of design or a total new design. The customer is involved in all phases, and they often have the possibility to do changes to the product until delivery. There is a high degree of customization in ETO supply chains, which often implies a long lead-time. A closer look at the ETO strategy is provided next.

2.2 Engineer-To-Order

There are different types of ETO and several definitions. Mello (2015, p 23) proposes a definition of ETO:

> *"ETO supply chain consists of multiple companies involved in a project to satisfy a specific customer order which requires a completely new design or different degrees of adaptation of an existing design that demands one-off production".*

As stated earlier, ETO supply chain implies that the decoupling point is located at the design phase (Cannas et al., 2018). The production process is driven by customer orders and involves physical and non-physical phases (Carvalho, Oliveira and Scavarda, 2015). Within an ETO supply chain there is no stock, as a result, the purchase order of materials and the entire project is performed based on a specific customer order (van Weele, 2018). The process in an ETO supply chain starts at the engineering phase and the products are designed and engineered in close collaboration with each specific customer (Rushton, Croucher, and

Baker, 2017). According to van Weele (2018), this results in a long lead-time, and as mentioned by Li (2008) the product volume in an ETO supply chain is small and the products are often one-of-a-kind. Other important characteristics of ETO are a high degree of customization and it is a project-based approach (Kjersem and Jünge, 2016). Because of the complexity and that each project is unique, suppliers rely heavily on skilled employees.

According to Wilner, Gosling and Schönsleben (2016), companies with an ETO supply chain face the challenges of undertaking order driven design and engineering activities from impatient customers who have last minute request for changes. They further state that this could lead to unpredictable workflows, rush jobs, out-of-date information, and distorted delivery dates. An important aspect of an ETO supply chain is that it provides firms with increased agility and flexibility which allows them to respond to rapid market shifts (Grabenstetter and Usher, 2015). Despite these advantages, Grabenstetter and Usher (2015) further state that the very nature of the ETO environment drives complexity because the products are produced and assembled in low quantities to individual customer specification.

For firms with an ETO approach, the engineering process is the largest controllable consumer of lead-time and is a core process that is almost never outsourced (Grabenstetter and Usher, 2015). According to Grabenstetter and Usher (2015), the engineering phase of a project could in some instances take up to one half of the total lead-time. This is also emphasized by Wilner et al. (2016) who state that since ETO products either have to be fully developed or adapted to customer specifications within order fulfilment, engineering hours contribute a substantial amount of hours to the delivery lead-time. As a result, ETO companies that have a shorter delivery time than other suppliers will gain a competitive advantage (Wilner, Gosling and Schönsleben, 2016).

2.2.1 ETO business process

A business process is the sequence of tasks that take a set of inputs and convert them into the desired output (Magal and Word, 2009). Hicks, McGivern and Earl (2000) divided an ETO business process into three phases: marketing, tendering, and production.

An ETO project starts with marketing which is a two-way process that seeks to develop customer awareness of the company and its products (Hicks, McGivern and Earl, 2000). This phase allows the company the opportunity to identify market trends, technical and non-

technical requirements as well as what potentially makes the customers choose a competitor. Thereafter, the company figures out if they will take the job. The decision is based on the requirements from the customer, commercial factors, and the likelihood for success (Hicks, McGivern and Earl, 2000).

The second phase is the response to an invitation to tender for a particular contract (Hicks, McGivern and Earl, 2000). This involves preliminary development of the conceptual designs and definition of components and systems. Several suppliers are contacted to find out who can deliver the components needed in a cost- and time efficient way and within the required specifications. In the third and last phase, there is development of an overall project plan and detailed design followed by purchasing, production, assembly, construction, and commissioning (Hicks, McGivern and Earl, 2000).

Since ETO companies usually are involved in all phases of the value chain, it is important to go thoroughly through these phases so that the project completes successful and delivers according to customer requirements.

2.2.2 Different types of ETO

Hicks, McGovern and Earl (2001) observed four types of ETO configurations. These typologies have been developed to classify the different forms of ETO companies (Hicks, McGovern and Earl, 2001). Further, they state that this framework is used to examine the impact of market changes on the configuration of production processes. Type I companies are the *vertically integrated companies*. They have their core competencies in design, production, assembly, and project management (Hicks, McGovern and Earl, 2001). Further, they mention that these companies have their competitive advantage from product and process knowledge. Thus, technical specifications can be matched with in-house knowledge. Furthermore, integration facilitates concurrency between activities and possibilities to reduce lead-time. Due to low value or irregular purchases, supplier power increases and provides an incentive for ETO companies to use modular designs with common components and systems (Hicks, McGovern and Earl, 2001).

Type II companies, *design and assembly companies* have their core competencies in design, assembly, and project management. The competitive advantage for these companies is in system integration and the co-ordination of internal and external processes (Hicks,

McGovern and Earl, 2001). Some companies can be placed somewhere between type I and type II companies, as they keep production of critical items in-house. These companies are reliant on a good relationship with their suppliers in order to reduce lead-time.

Type III, *design and contract companies* have their core competencies in design, project management, and logistics. Their competitive advantage is in system integration and coordination of internal and external processes (Hicks, McGovern and Earl, 2001). All physical processes like production, construction, and assembly are outsourced, while design is done in-house. These companies use some standard components and systems that make it possible to reduce costs and lead-time. It is necessary for these companies to share design information and knowledge with suppliers; thus, it can be difficult to retain product leadership as competitors may have access to detailed product knowledge (Hicks, McGovern and Earl, 2001).

Type IV, *project management companies,* is doing consultancy that manages contracts on behalf of a client (Hicks, McGovern and Earl, 2001). All activities, including design, are outsourced. These companies´ core competencies lie in project management, engineering, and logistics.

There are several strategies to improve performance in ETO projects (Ahmad et al., 2016, Semini et al., 2014, Kampker et al., 2014):

- Concurrent engineering
- Standardization
- Modularization

These are described next.

2.3 Concurrent Engineering

Concurrent engineering (CE) is defined by Pennel and Winner (1989) as a systematic approach to the integrated, concurrent design of products and their related processes, including production and support activities. They further explain that CE is characterized by a focus on the customer´s requirements and priorities and the principle that quality is a result of the improvement of processes. Ahmad et al. (2016) also elaborate that CE introduced the

concept of simultaneous or parallel engineering in order to reduce project time. In figure 6 sequential engineering is compared with concurrent engineering. As illustrated, CE enables time to clarify design to improve quality and saves time for project execution (Kjersem and Emblemsvåg, 2014).

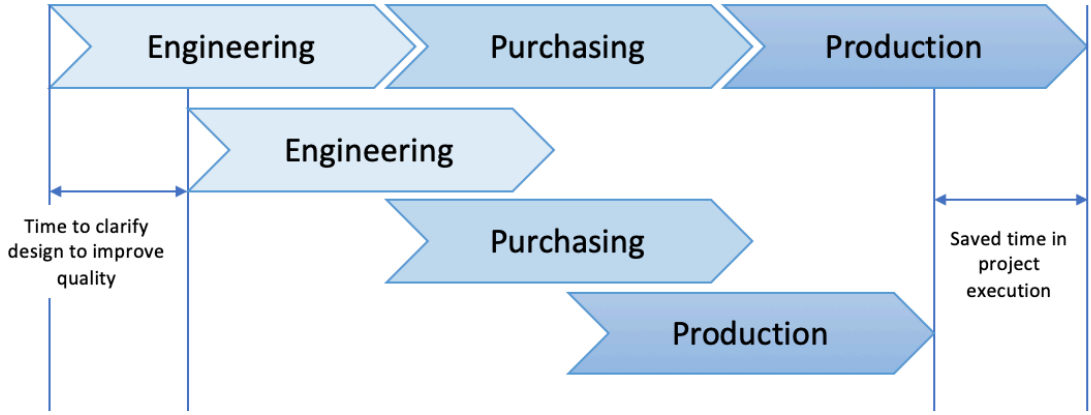

Figure 6: Sequential engineering compared with concurrent engineering (Source: Kjersem and Emblemsvåg, 2014)

Bhuiyan, Thomson and Gerwin (2006) explain that multifunctional teams, concurrency of product- and phase development, integration tools, information technologies, and process coordination are among the elements that enable CE to improve project performance. Further, it is emphasized that utilizing the appropriate human resources at the right time is critical and could accelerate development by minimizing the need for rework. Anumba and Evbuomwan (1997) argue that CE is an answer to the need of being more competitive in terms of price, quality, durability, and be more responsive to changes.

According to Pieroni and Naveiro (2006), CE aims to do the job right the first time because of two fundamental observations:

1. Changes become more costly when they occur late in a project.
2. Doing the different project phases in parallel enables the project to be completed sooner, compared to doing the phases in sequence.

Pieroni and Naveiro (2006) further argue that new requirements for production, maintenance, and operation must be addressed during earlier stages of engineering and that the dependencies among them must be analysed in order to execute the activities in parallel.

The information flow in the CE approach is bi-directional and decisions are based on consideration of downstream and upstream inputs (Pennel and Winner, 1989). A study conducted by Bhuiyan, Thomson and Gerwin (2006) showed that the overlapping that takes place in CE processes is dependent on a high level of communication and coordination among functions in order for CE to be successful. Benefits that could be achieved through CE are quality improvements, cost reductions, decreased development time, and better interaction (Pennel and Winner, 1989). On the other hand, overlapping engineering and production activities is seen as one of the main sources of uncertainty since engineering work is not finalized before production takes place (Hicks, McGovern and Earl, 2001). Mello, Strandhagen and Alfnes (2015b) experienced that a high number of customer changes and overlapping engineering and production lead to increased delays and lead-time.

2.4 Uncertainty in ETO Projects

Engineering is an essential phase in ETO projects. The uncertainty in engineering is higher compared to the uncertainty in production. Engineering requires a higher degree of customization and variation, which increases the level of uncertainty. Conversely, production is more standardized and repeatable, which means that it is less uncertainty connected to this process.

2.4.1 Engineering Changes

According to Iakymenko et al. (2018), engineering changes (ECs) based on an individual customer order are highly common and difficult to avoid. ECs, engineering design changes, and product design changes are challenging in ETO projects. Uncertainty in design and engineering will lead to further uncertainty connected to drawings and technical details, which can affect the lead-time of the project. Table 1 shows different uncertainty elements in an ETO project.

Uncertainty elements	Relevant stage
Product changes after the production process starts	Manufacturing and assembly
Delay in delivering the detailed engineering drawings	Engineering
Occurrence of unpredictable events	Whole life cycle
High number of quality problems	Engineering, manufacturing
Self-over-evaluation of partners on their skills	Concept design, engineering
Delay to deliver equipment	Procurement
Poor quality of design alternatives	Concept design
Poor risk management	Project planning and detailed design
Inadequacy of supplier competence	Procurement

Table 1: Uncertainty elements within the project lifecycle (Source: Haji-Kazemi et al., 2015)

One of the most challenging issues in the construction business is the delay in product delivery, and a large number of projects fail to meet their objectives (Haji-Kazemi et al., 2015). Further, Haji-Kazemi et al. (2015) mention that many authors state that the growing technology, global economy, and information technology are bringing more complexity to projects and their environments. Moreover, the complexity makes it more difficult to bring projects to successful completion. In an ETO environment, design, engineering, production, and purchasing activities are often performed concurrently. Customized components have often a long lead-time, and therefore, they are ordered early in the project (Iakymenko et al., 2018). In a situation where a new component with long lead-time is needed late in the process, changes can potentially result in significant costs and delays. Furthermore, CE makes the situation more complex and difficult (Haji-Kazemi et al., 2015).

2.4.2 Early Warnings

As stated in Haji-Kazemi et al. (2015), Early Warnings (EW) indicate if a project may fail or need urgent changes. The concept of EW was first discussed by Ansoff (1975) and was later supported by Nikander (2002) (Haji-Kazemi et al., 2015). It is important to observe and evaluate information in order to identify potential problems. Project problems do not appear overnight. Thus, it is usually possible to find some of the most likely factors that contribute to project problems and identify signs of how to solve the problem (Haji-Kazemi et al., 2015). So, the goal is to identify problems connected to a project early enough to avoid big changes, extra costs, and longer lead-time.

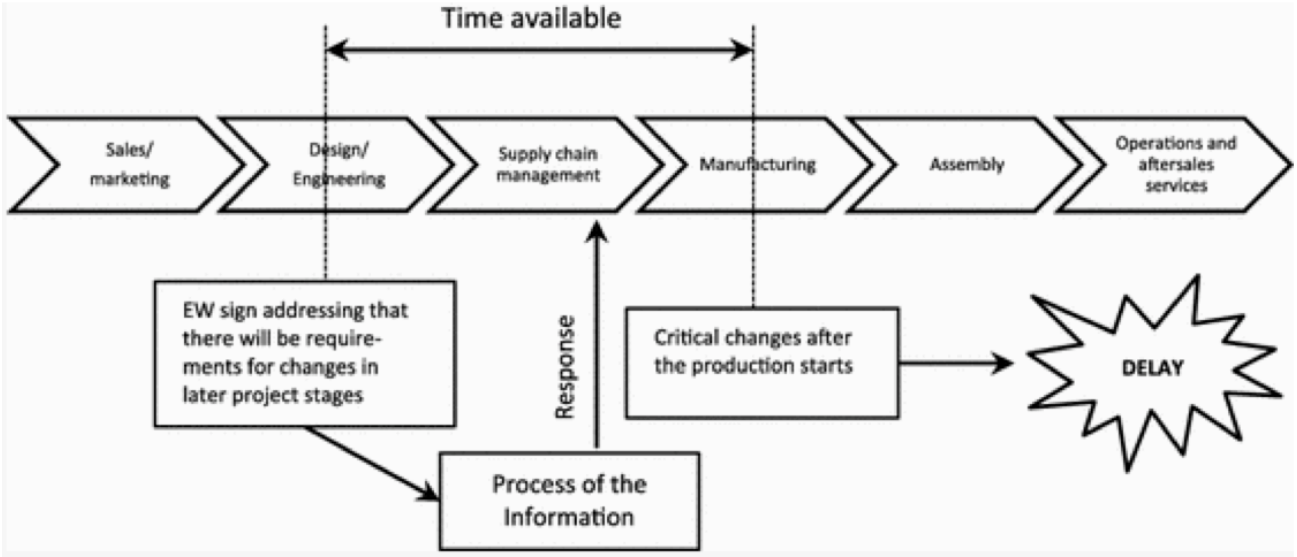

Figure 7: Identification of EW signs (Source: Haji-Kazemi et al., 2015)

Figure 7 depicts that early warnings should be identified at the design or engineering phase. If warnings are detected, the information should be processed to the supply chain and changes need to be carried out. If early warnings are identified after production start, it could lead to significant delays. Vaagen and Masi (2019) elaborate on how "front-end loading" or "pre-project planning" effectively involve customers early to pursue objectives that may change during the project. This will probably increase the amount of time and cost connected to early project phases, however, it can reduce the impact of disturbances and changes. Furthermore, they state that there are limited projects that have implemented this method. Many customers hesitate to share key technical and market information. Another reason is that collaboration and information sharing solutions are needed to fully leverage this approach. Next, standardization is proposed as an approach to decrease uncertainty and complexity.

2.5 Standardization in business projects

Most companies seek standardization of processes and products. According to Fixson (2006), it was a demand already in 1914 from an automotive engineer to standardize parts in the production of cars. This was facilitated in order to enable a mix-and-matching of components and to reduce costs. Furthermore, Kampker et al. (2014) explain that standardization of product components has been an approach to reduce product complexity and that modularity has been an important concept for standardization.

Lampel and Mintzberg (1996) described a variety of strategies within standardization and customization. These strategies are *pure standardization* that is based on a dominant design

that will suit most of the buyers. *Segmented standardization* means that the products are standardized within a narrow range of features. A basic design is modified to cover different product dimensions. However, it is not based on individual customer requests (Lampel and Mintzberg, 1996). *Customized standardization*, also called modularization, mean that the customers can select standardized components from a number of predefined options. Thus, assembly is customized, while fabrication is not (Lampel and Mintzberg, 1996). *Tailored customization* is a strategy where the product prototype is presented for the customer and the customer can come with individual wishes to tailor the product. The customization goes backward to the fabrication phase but not to the design phase (Lampel and Mintzberg, 1996). Finally, the last strategy presented in Lampel and Mintzberg (1996) is *pure customization*. Here are all phases highly customized, all the way from the design phase to the distribution phase.

In Semini et al. (2014), the authors present and discuss the firm Ulstein Shipyard and their focus on standardization in an ETO environment. Ulstein Shipyard offers a custom design for each specific customer, or a standard design where the ship design is partly standardized. Within standard design, concepts and design are developed. Engineering is performed to a large degree before a specific customer is known and involved in the process. After contract signing, the level of customer involvement is limited, the number of ECs is minimized, and only predefined proved solutions that do not require additional engineering are generally accepted. Semini et al. (2014) also highlight some critical risk factors involved when choosing to offer their customers standardized products. Firstly, demand may turn out lower or different than expected, which could undermine the possibility of spreading the costs of design, engineering, and purchasing activities over enough number of vessels to realize expected savings. Secondly, there is a risk of difficulties when starting to produce, such as unexpected problems, higher costs, and longer lead-times the first time a standard ship is produced. In figure 8 and 9, we can see the activities performed and CODP in both customized design and standardized design as discussed by Semini et al. (2014).

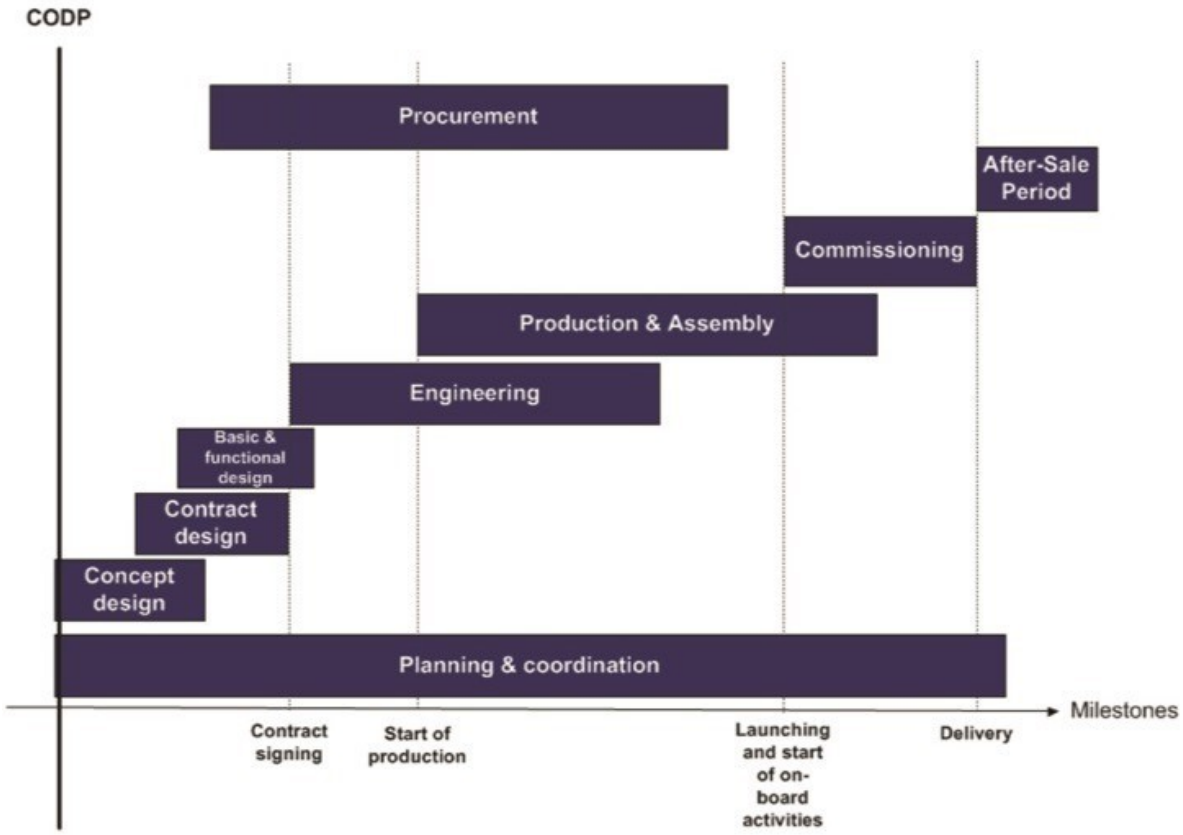

Figure 8: Activities and CODP in customized design (Source: Semini et al., 2014)

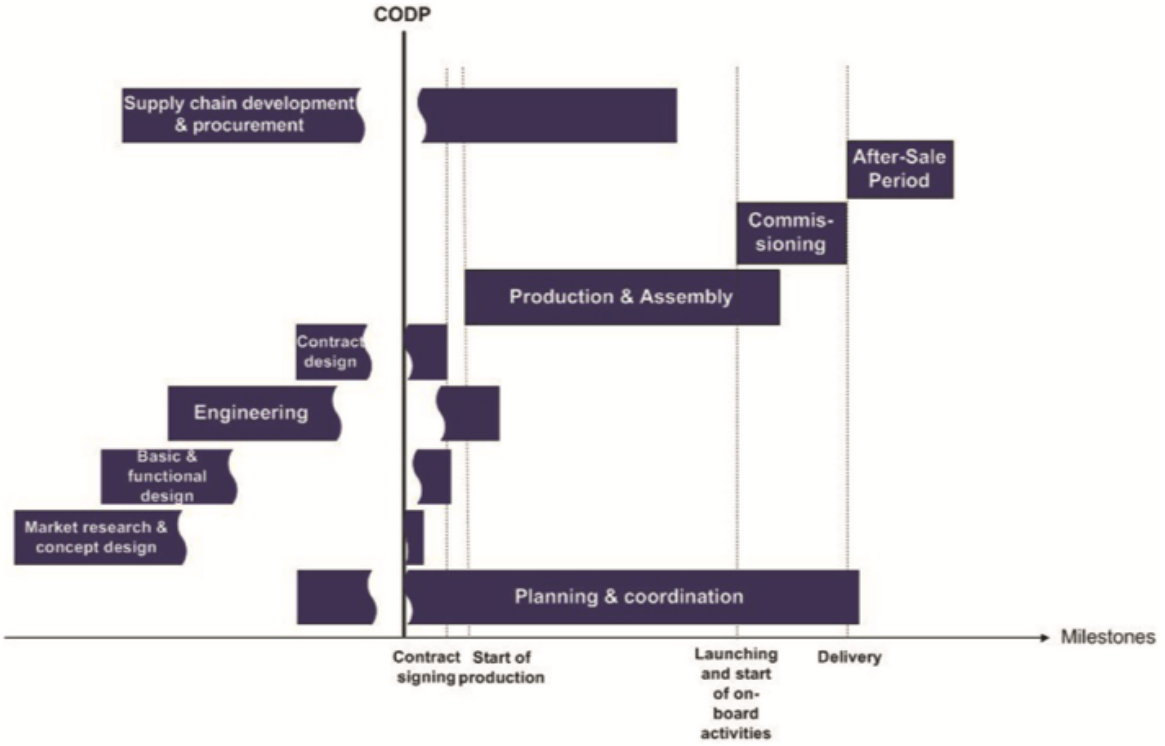

Figure 9: Activities and CODP in standardized design (Source: Semini et al., 2014)

2.5.1 Modularity

Economic and demographic changes in consumers' preferences have raised demand from customers to purchase customized products for the price of products that are mass-produced (Fixson, 2006). Duray (2002) proposes that modularity of products can reduce the range of components while at the same time offer a wider assortment of end products. Further, modularization allows parts of the product to be produced in volume (standard modules) and that product uniqueness is achieved through combinations or modifications of the modules in final assembly. Dekkers (2006) states that reduced engineering work will be possible if the product design consists of standard modules, basic modules, and optional modules. In other words, the final product is divided into different modules, and these modules can be mixed to create new variants of the products. The customer will then have the opportunity to choose from different options to create the product they demand (Fixson, 2006). For ETO companies, modularization could be a possibility to reduce the range of components, while still be able to deliver unique products.

According to Hellström and Wikström (2005), one of the key drivers behind modularity is the possibility of economy of scale through standardization of products and production. The need for flexibility in the production of products is generally lower with modular products (Kampker et al., 2014). Hence, modular products improve response to a specific customer request, lead-time, at the expense of product flexibility (Dekkers, 2006). He further states that developing each product on its own offers the best flexibility for the market. Although the challenges related to productivity and lead-time will still be present when performing engineering tasks for each customer specific product. Companies in high wage countries are increasingly challenged due to the necessary differentiation and cost pressure (Schuh et al., 2014). Modularization could be an approach for handling these types of challenges.

Duray et al. (2000) state that modularization allows customers to demand a greater variety of products with reduced lead-time. During the design and production phases, modules can be altered, or components produced to fit the requirements from the specific customer, while during the assembly and use phases, modules can be arranged or combined according to customer specification (Duray et al., 2000). This results in a high or low degree of customization for the end product and is illustrated in figure 10 below.

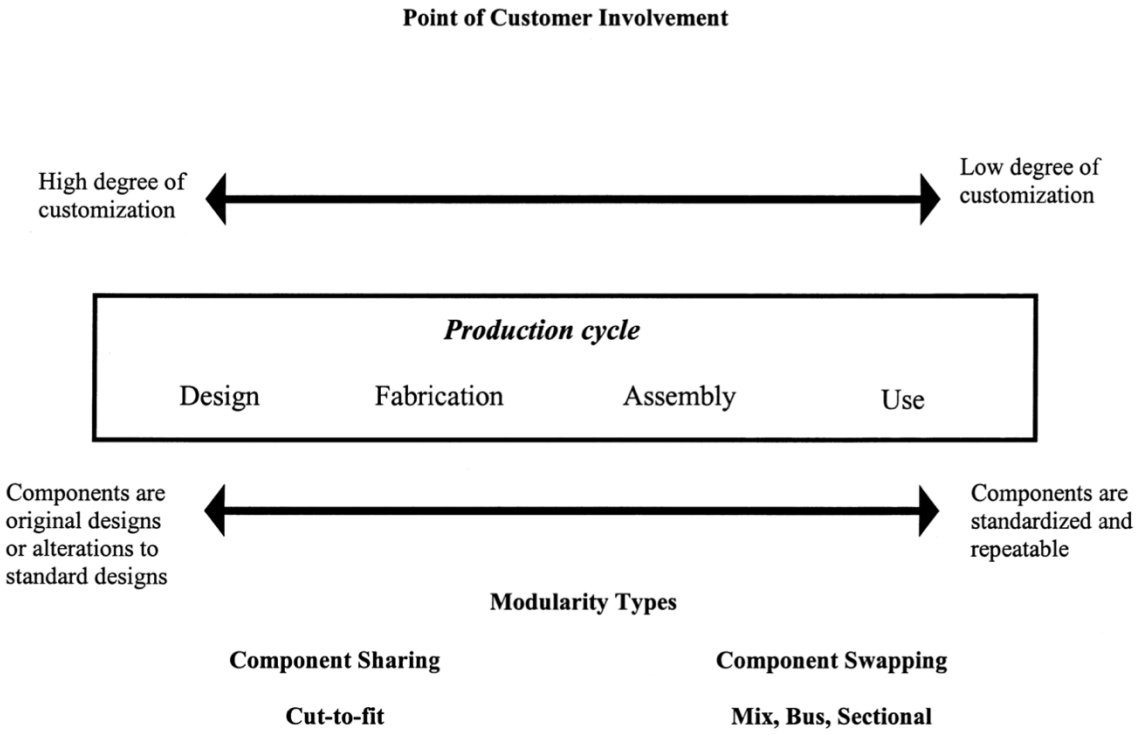

Figure 10: Customer involvement and moduarity in the production cycle (Source: Duray et al., 2000)

As illustrated in figure 10, component sharing and cut-to-fit modularity are the ones that offer the highest degree of customization, and adaption of these modules is performed at earlier phases of the production process, making them the most suitable for ETO companies. According to Duray et al. (2000), component sharing involves that common components are designed into a product and cut-to-fit alters the dimensions of a module before it is combined with other modules. Component swapping, mix, bus, and sectional are the ones that offer the lowest degree of customization. Duray et al. (2000), elaborate that component swapping involve the ability to switch options on a standard product. Mix, bus, and sectional involves adding a module to an existing series, mixing modules together, or arranging them in a unique pattern (Duray et al., 2000).

2.6 Project management

A project has a specific relational context, time-limitedness, value creation properties, high complexity, high degree of uncertainty, and limited possibilities for standardization (Hellström and Wikström, 2005). Pinto (2016) provides some elements that describe projects, these elements can be complex and a one-time process, limited by budget, schedule, and resources. Projects are developed to resolve a clear set of goals and are customer focused. Furthermore, projects have short product life cycles, narrow product launch windows, increasingly complex and technical products, and global markets. The product life

cycle demonstrates the logic that governs a project and helps to develop plans for carrying out the project. The phases of a simplified life cycle model in Pinto (2016) are conceptualization, planning, execution, and termination. Conceptualization refers to the initial goal and technical specifications for the project. During the planning phase, all detailed specifications, schedules, and other plans are developed. Execution is the phase where the actual work is being done, for instance, the production of a thruster. Termination happens when the project is transferred to the customer and it is formally closed. figure 11 illustrates the project life cycle phases. Most of the work associated with a project is being laid under the execution phase.

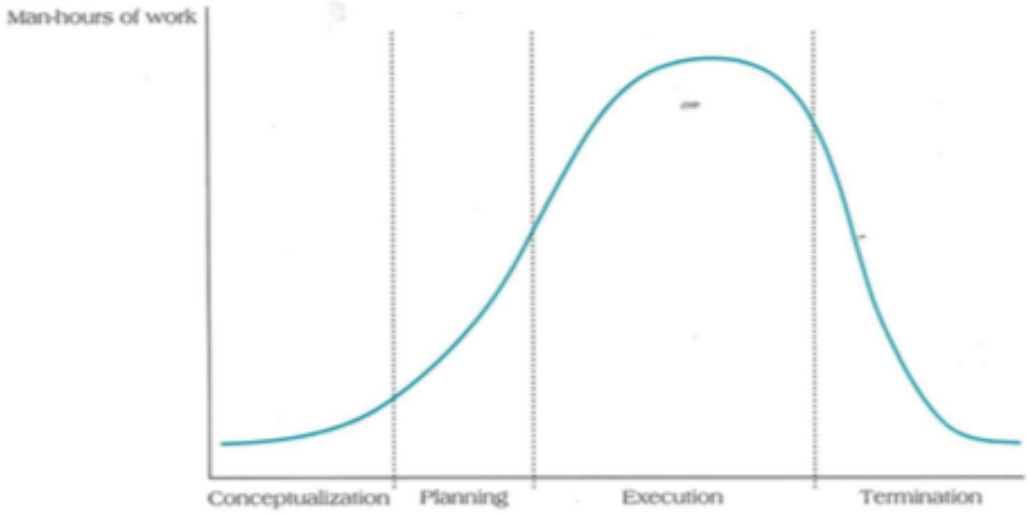

Figure 11: Project Life Cycle Phases (Source: Pinto, 2016)

Pinto (2016) highlights some strengths and weaknesses with project management. One of the strengths is that it is suited for different environments. Another advantage is that power and control are the same for both project managers and department managers. The movable and shared resources in a project is also a positive side with project management as expertise can be shared across the organization. However, a weakness with project management is that several managers can give mixed messages, which possibly can create conflicts (Pinto, 2016).

From the characteristics that are put forward early in this chapter, it clearly shows that ETO projects are complex. Each project has uncertainty connected to it, which is the result of a high degree of customization and that each project is unique.

2.7 Outsourcing and offshoring

Outsourcing and offshoring are often used interchangeably without clear definitions (Halse and Nujen, 2018). Outsourcing is when a company place activities at an external supplier, typically in a low-cost country. Offshoring is the outsourcing of activities to a low-cost country, while still being internally in the company. There is a trend with increased outsourcing and offshoring and a high focus on quality and complex ships (Held, 2010). Furthermore, Held (2010) states that this has caused many European shipyards to move towards system integrators. Thus, many of the full shipyards have become assembly shipyards. Companies focus on their core competencies and outsource other activities (Martin and Towill, 2000). The perception of the role of production as a strong competitive advantage has changed to a commodity that is outsourced to external suppliers (Nujen and Halse, 2018).

The main reason that many companies with an ETO approach choose outsourcing or offshoring is connected to costs savings due to the low labor costs and low cost of raw materials (Halse and Nujen, 2018). Further, it is possible to access a larger talent pool and save money by not having to hire new employees. Outsourcing can thus in turn contribute with important knowledge from external relations that is necessary to maintain competitiveness. New research illustrates that the most innovative companies are the ones that benefit from outsourcing and offshoring, due to the fact that they gain a combination of local and global knowledge (Nujen and Halse, 2018).

On the other hand, there are some disadvantages to outsourcing and offshoring. Since production occurs in another country, it is easy to lose control, while issues with communication can occur (Patel, 2017). It is also a challenge with quality, especially connected to outsourcing. One might not achieve the quality that is desired. A high degree of transaction-specific investments increases the possibility for opportunism from the supplier side, which can make outsourcing challenging (Halse and Nujen, 2018; Buvik 2002). Offshoring and outsourcing represent longer transportation lead-times, which further can affect the delivery time for the final product.

2.8 Communication

In a complex business environment like ETO, it is more important for all parties to communicate effectively (Yankelevitch and Kuhl, 2015). Organizational communication can, according to Kelly (2000), be defined as the process by which information is exchanged and understood by two or more people, usually with the intent to motivate or influence behaviour. Communication also implies possibilities for miscommunication. People from different cultures and backgrounds, who speak different languages, may face challenges when coordinating multiple products across continents and time zones (Yankelevitch and Kuhl, 2015).

Breakdowns in communication can take place at any point in the process. According to Kelly (2000), breakdowns occur when the sender fails to influence the receiver as intended. This could be because the sender fails to code the message so that it is not heard or received. Further, the receiver could also end up decoding the message inaccurately, misinterpreting the intent, and respond inappropriately (Kelly, 2000). Cultural and social differences are important and may affect how one interprets a message. Hartley and Bruckmann (2002) state that some degree of common background is essential for exchanging messages. Further, that differences in norms, attitudes, and beliefs make communication between different cultures a challenge.

There are multiple barriers for communication, and these are both interpersonal and organizational. According to Kelly (2000), the interpersonal barriers include perception and perceptual selection process, semantics, channel selection, and inconsistent verbal and non-verbal communication. Further, Kelly (2000) states that the organizational barriers include physical distractions, information overload, time pressure, technical and in-group language, status differences, task, and organizational structure requirements, and absence of formal communications channels.

2.8.1 Communication in ETO projects

According to Rajhans (2018), a project-based organization differs from general organizations, because a project is the primary business mechanism for coordination and integration in the organization. In addition, unless the project teams are able to manage communications in the right way, the time spent on developing plans and controls could be

wasted since the right information may not reach the right people, or is ignored or misunderstood.

Due to the fact that various stakeholders are involved in projects, communication and stakeholder management is essential. Stakeholders can be customers, distributors, suppliers, employees, or shareholders. According to Rajhans (2018), it is not possible to meet the expectations of stakeholders without the proper flow of information. Furthermore, incomplete or wrong communication generates wrong perceptions, while effective communication can help manage expectations and perceptions of stakeholders.

Rajhans (2018) states that effective communication management is systematic initiatives directed towards planning, monitoring, and controlling all communication channels within an organization. Communication management also includes developing cooperate communication strategies, designing internal and external communication directives, and managing the flow of information (Rajhans, 2018).

2.9 Coordination in ETO projects

A supply chain may consist of multiple companies that perform various activities. According to Mello (2015), the objective of coordination is to ensure that each individual company is managing their activities, so the performance of the whole supply chain is optimized. Further, Mello (2015) explains that coordination consists of defining the structure, policies, and goals to improve the performance of the overall system.

Problems with coordination within an organization are dependent on the structure and goals (Mello, Strandhagen and Alfnes, 2015b). A common goal is important for achieving coordination. An established pattern of decisions, communication, and interaction between supply chain members enables coordination to avoid sub-optimization (Mello, 2015). According to Mello, Strandhagen and Alfnes (2015b), the challenge of coordination increases when interdependent activities are performed by different partners. The authors explain that this is due to the diversity, uncertainty, and interdependence of activities and that more coordination is necessary to achieve consistency of the decisions made. Organizing activities in individual business units can increase efficiency, however, it can also increase the need for communication and decisions when these activities are performed (Mello, Strandhagen and Alfnes, 2015b).

For ETO companies there are three processes that require coordination, these are sales and marketing, engineering, and production. These processes require specific coordination mechanisms that can be used in an environment with little standardization and limited repeat orders (Mello, Strandhagen and Alfnes, 2015b). It is also stated by Mello, Strandhagen and Alfnes (2015b) that high project complexity is a consequence of deep product structures, sporadic demand for items requires various methods of production and concurrent engineering.

2.10 Summary of theory

The literature used in this chapter sought to map existing advantages and challenges, and their impact on performance in an ETO supply chain. The theoretical framework describes where decoupling points are placed in different production strategies, with a focus on ETO supply chains. For ETO supply chains, CODP is placed early at the design phase. Further, four types of ETO are described dependent on how they operate and what activities they outsource. These are vertically integrated companies, design and assembly companies, design and contract companies, and project management companies. We have also seen that CE, standardization, and modularization are strategies that can improve ETO performance with cost and lead-time reduction. However, CE can also increase lead-time and uncertainty. Standardization and modularization can impose a risk connected to demand and could reduce the opportunity for highly customized products. ECs are common for ETO projects, and EW is an indicator if a project may fail or need urgent changes. To ensure successful outsourcing and offshoring of activities, good project management is important. Furthermore, the theoretical framework shows that the outsourcing and offshoring of activities are a possibility to cost savings especially. On the other hand, it may occur issues with communication and loss of control. The theory also elaborates on the importance of good communication and coordination in a complex business environment that ETO is.

Semnini et al. (2014) elaborate that the shipbuilding industry delivers a wide range of products with a varying level of customization, and other product and market variations, which makes this production complex. Therefore, we interviewed different maritime equipment suppliers in order to investigate how their ETO supply chain work, and what impact it has on their performance. We will go further into our selection of participants in the methodology chapter and later in the case description.

3.0 Methodology

In this chapter, the methodological approach for the research is presented. First, our research design is presented with a combination of an exploratory and a descriptive approach. Thereafter, we give a description of the case study where a multiple case study design is being used. Following, a description on how data are collected through qualitative and quantitative research. Lastly, we elaborate around the quality of the research.

3.1 Research design

Gripsrud, Olsson and Silkoset (2004) explain that research design is a description of how the analytic process should be designed in order to solve the specific problem. Design is chosen based on how much one knows about the topic and which ambitions one has to analyse. Design can be divided into explanatory, exploratory, and descriptive research (Saunders, Lewis and Thornhil, 2012). According to Saunders, Lewis and Thornhill (2012), explanatory research focuses on studying a situation or a problem in order to explain the relationship between variables. Exploratory research aims to seek new insight into phenomena with varying levels of depth. Silver et al. (2013) argue that exploratory research in some ways is like detective work where one searches for clues to find out what and why something happened or is taking place. A variety of sources can be used to provide insight and information. Those doing exploratory research should have a flexible attitude when collecting information. Follow-up questions will be beneficial to ask respondents, in order for the researcher to get a deeper understanding. Descriptive research seeks to describe something. It is a more structured approach to data collection compared to exploratory design (Silver et al., 2013). They also mention that descriptive design provides for a test of the hypothesis and that descriptive design is often used additionally to exploratory to meet research requirements.

Research in general is meant to provide new insight into a phenomenon. Furthermore, Silver et al. (2013) state that it may be dangerous to define a design by the applied techniques and that it should rather be defined by objectives. However, this research study has an exploratory and descriptive approach as we seek to gain new and broader insight into the ETO topic at the same time as we want to find out why something may occur.

3.2 Case study

According to Yin (2018), the choice on whether a case study is relevant or not depends on the research question. Since we will go in-depth and gain insight of ETO in the maritime industry, a case study approach is being used. Further, we used a multiple case study as the case study contained more than a single case company. The advantage of this type of study is that the evidence often is considered more compelling and the overall multiple-case study design is therefore regarded as being more robust (Yin, 2018). However, it is important that each case is selected carefully so that it predicts similar results or contrasting results but for anticipatable reasons (Yin, 2018).

3.3 Data collection

The collection of data can be divided into two types, primary and secondary data. Primary data is data collected by the researcher and is a more time-consuming process. Primary data can be collected through direct communication, observation of people and document analysis (Gripsrud, Olsson and Silkoset 2004). Secondary data was originally collected as primary data by other researchers. This type of data will be time- and cost efficient, nevertheless, the validity may be lower as the data is collected for other purposes (Gripsrud, Olsson and Silkoset 2004).

3.3.1 Sources of evidence

One of the strengths in a case study data collection is the possibility to use many different sources. In addition, it will lead to a better overall quality of the case study compared to those relying on single sources of information (Yin, 2018). According to Yin (2018), there are six sources of evidence that are commonly found in case study research, these are *documentation, archival records, interviews, direct observations, participant observation,* and *physical artifacts*.

1. *Documentation* will usually be important for all case studies (Yin, 2018). Documentation can be collected through different approaches like e-mail, letters, administrative documents, reports, or formal studies, and can be categorized as secondary data as it is not collected for the purpose of this research. In addition, it is important to use this information carefully as it may not always be accurate. Documentation can be useful to support our findings from other sources, for instance

when verifying the correct spellings and titles of people and organizations (Yin, 2018).

2. *Archival records* like public use files, service records, survey data produced by others, organizational records, maps and charts of a place can be used in conjunction with other sources of information in producing a case study, however, the relevance of the records will vary from case study to case study (Yin, 2018).
3. *Interviews* is seen as one of the most important sources of case study evidence as it will be more of a conversation where you can ask follow-up questions rather than structured queries (Yin, 2018). This allows the researcher to get a deeper understanding of the topic that is studied. Furthermore, Yin (2018) states that well-informed interviewees can give important insight.
4. *Direct observations* can be done formally by observing meetings, factory work, and side-walk activities, or more informally throughout fieldwork, such as the way interviews are collected (Yin, 2018). Direct observations are often useful as additional information to the research.
5. *Participant observation* means that the researcher may have a variety of roles while doing the fieldwork. It can be as a passive observer, or even being participatory in the actions being studied (Yin, 2018). This type of source can give valuable data that is difficult to obtain from any other source since it gives a viewpoint from someone inside a case. However, there may be a challenge with the participant being biased using this source of evidence.
6. *Physical artifacts* can for example be a technological device, a tool, instrument, or other physical evidence (Yin, 2018). When it is relevant, it may be an important source of evidence. Nevertheless, in most of the case studies it has proven to be of less relevance.

In this thesis, the primary data is gathered through qualitative interviews. In addition to this, a quantitative survey was developed to supplement the qualitative data. Both of these data collections are primary data as the main purpose of it being collected for this research. In order to investigate the production strategy ETO and if it is a competitive advantage for maritime equipment suppliers, secondary data through literature search was needed in order to get a better understanding of the research area. According to Yin (2014), the act of describing the relevant literature has two purposes. Firstly, it is meant to show that the researcher has researched sufficient literature for the study and that the researcher has

knowledge about the topic. Secondly, the literature is supporting the importance and findings of the research. In addition, it gives insight into what type of research has been done on the area and it gives a deeper insight into what is needed to be further researched.

After conducting the literature search, both advantages and disadvantages could be found with ETO. Thus, the literature findings could be used to explore these advantages and disadvantages in the case study to find out if ETO actually is a competitive advantage or not. CE was described as both an advantage and a disadvantage in the literature. Standardization and modularization were mentioned in several articles as a possibility to decrease costs and lead-time in ETO projects, consequently, we found it interesting to investigate this further. Furthermore, other aspects were found that could affect the result of an ETO supply chain, like communication, outsourcing, and coordination.

3.3.2 Qualitative interview

Doz (2011) explains that qualitative research is uniquely suited to discover the unknown elements of organizational processes. By using a qualitative research method, we were enabled to go in-depth with our research and get a deeper understanding of the industry and the problems involved. Qualitative research can ask questions like what, why, and how and enables us to discover unforeseen events. However, it does not give an answer to "how many". Qualitative researchers typically rely on four methods for gathering information. These four are participating in the setting, observing directly, interviewing in-depth, and analysing documents and material culture (Marshall and Rossmann, 2006). Qualitative research can be difficult to statistically determine the validity of a study (Silver et al., 2013). To avoid this, Silver et al. (2013) state that a researcher should be careful and precise when designing the study, all the way from developing questions to reporting of results. Further, Silver et al. (2013) mention viewing questions from different perspectives as a method to increase the validity of the research. A third approach is to combine qualitative and quantitative methods in one study (Silver et al., 2013).

In this case study, interview was the main source of data collection. Interview is important as it allows us to be open minded and go in-depth on the topic. Saunders, Lewis and Thornhill (2012) categorize interviews as either structured, semi-structured, or unstructured. This study benefited from using semi-structured interviews with some predefined questions. However, they did vary from interview to interview. Furthermore, the order of the questions

varied depending on the conversation. Follow-up questions were also used when more information was needed. All the questions were made so they were not leading the respondent in any direction or making them feel uncomfortable. In total, six different maritime equipment suppliers and one ship designer were interviewed. Optimally, it would be a better basis for the data analysis with more respondents. What eventually affected and weakened the data gathering was the situation with Covid-19 which occurred in March 2020. The companies declined further access to its premises and organisations; thus, it was difficult to get more respondents to conduct interviews with. As a result, this thesis will focus on maritime equipment suppliers as most of the data come from those types of companies.

3.3.3 Quantitative survey

Watson (2015) states that quantitative research involves measurement and assumes that the phenomena under study can be measured, and that the objective is to analyse data for trends and relationships in order to verify the measurements made. Surveys are often used for quantitative research, these could be performed in person, over the phone, on paper, or online. A survey will not make it possible to experience behaviours, sense making, and emotions. However, surveys are convenient for gathering large amounts of data to describe samples and populations (Watson, 2015). Further, it is explained that trough quantitative studies there is a production of numbers that shall be interpreted before a conclusion may be drawn. The result of the data are often visualized in tables and graphs.

One issue with quantitative research is that key terms may not be interpreted in the same way as it usually is no possibility to explain what is meant. Further, this can affect the measurement process and validity of the findings as people may answer on different terms (Bryman, 2001). To make sure that the respondents understood the question, words that could be hard to interpret and understand were avoided. For instance, in the interviews most respondents were not familiar with the term ETO, therefore, it was needed to use other words than ETO or Engineer-To-Order. In the survey, it was asked what production strategy they used with describing the main characteristics instead of using the terms (See appendix 2). Since the survey was completed online, it was not possible to ask follow-up questions to increase knowledge and understanding of their answers.

After conducting the in-depth interviews, the online survey was developed with the purpose to supplement the qualitative findings and increase the validity of the study. The results from

the in-depth interviews gave insight which helped to develop questions that could give answer to the research problem. The survey had much of the same questions as the interviews since the purpose was to supplement and validate the research. Most of the questions were multiple choice questions with the opportunity to elaborate if the predefined answers were not suitable. In total, the survey was sent to 54 maritime equipment suppliers where 27 of these ended up answering. All 27 were found valid. There also occurred problems connected to gathering enough data from the survey. During the Covid-19 restrictions, we experienced that the number of respondents stagnated. Due to the situation, a waiting period of two weeks was given before the mails were sent out to several companies, and a reminder to those who previously had received the survey.

3.4 Quality of research design

Yin (2018) present four criteria for judging the criteria for research design. These four are construct validity, internal validity, external validity and reliability.

3.4.1 Construct validity

"Construct validity intend to identify correct operational measures for the concept being studied" (Yin, 2014, p 46). Construct validity can be strengthened by using multiple sources of evidence, establishing a chain of evidence and to have the draft case study report reviewed by key informants (Yin, 2018). In this case study, both interviews and survey are being used, which are strengthening the study compared to having only one source. However, it could be advantageous to conduct several data collections from other sources than interview and survey to get a deeper insight and stronger construct validity. For instance, e-mails and other communication tools could give us insight in the interaction between customer and supplier to see how communication works and how often changes occur during the project.

3.4.2 Internal validity

Internal validity is mainly for explanatory studies (Yin, 2014). A problem with internal validity is that it may make inference. Inference occur every time an event cannot be directly observed (Yin, 2014). It cannot be said for sure that all rival explanations and possibilities have been considered, thus, the internal validity is weakened (Yin, 2014).

3.4.3 External validity

Another issue in qualitative method is the external validity. External validity reflects how accurately the results represent what is studied (Ellram, 1996). It cannot be said for sure that the findings can be generalized across organizations. There are probably many Norwegian maritime equipment suppliers that did not answer the survey or attended interviews that could possibly have given this study another point of view. Focus on single-case studies is often inconsistent with the requirements of statistical sampling procedures (Gomm, Hammersley and Foster 2000). In this research, a multiple case study that strengthens the external validity has been used.

3.4.4 Reliability

Reliability means to be able to trust that the research is correct. Thus, if the same study were to be conducted again, the researcher can follow the same procedures and will find the same results and conclusion (Yin, 2018). The goal is to minimize bias and errors. Qualitative research is criticized as being too subjective. This critique lies in the findings relying too much on the researcher views and the relationship with the people studied (Bryman, 2001).

Another challenge is that it may be difficult to replicate. There are few standard procedures to be followed, and the researcher is the main instrument of data collection and is the one that decides what to focus on. Further, the people that are being studied can be affected of the researcher's mood, personality, gender etc. Due to these factors, it can be difficult to replicate the qualitative findings (Bryman, 2001). This study has semi-structured interviews, meaning that follow-up questions were asked, and questions could differ from interview to interview. Therefore, there might be difficult to get the exact same information on a later point of time. However, there is a high chance that when conducting the interviews again, the same answers and information can be extracted and point in the same direction as in the first interview.

As mentioned, the goal is to minimize bias and error in research. However, it is important to have in mind that bias can easily occur in research, therefore it is needed to take into consideration how it may influence the study´s conclusion (Pannucci and Wilkins, 2010). There are different types of bias, for instance the selection bias and the interviewer bias. The selection of respondents was not random, which imposes a risk for bias. However, the companies that were chosen for this study were sure to be relevant for the research. The

companies that were invited to take the survey were identified as maritime equipment suppliers delivering customized products. There were probably several other companies that could have been invited to take the survey, but the Covid-19 restrictions limited our access to more companies. Therefore, the sample may not be representative for the whole population intended to be analyzed. Interviewer bias refers to a difference in how information is solicited, recorded, or interpreted by the interviewer (Pannucci and Wilkins, 2010). The answers might be interpreted in another way in this study than it would be if conducted by other researchers. However, follow-up questions were asked in case anything was unclear, which should strengthen the understanding and decrease interviewer bias.

4.0 Case description and findings

This chapter will first give a description of the case study, thereafter, present the main empirical findings. The case description gives an overview of maritime equipment suppliers and their supply chains. The findings are presented with the different production strategies and their advantages and disadvantages. Thereafter, a walkthrough of the challenges in a project will be given. Further, it is explained how the respondents answered the questions concerning standardization and modularization. Lastly, concurrent engineering is presented with the advantages and disadvantages it brings.

4.1 Case description

The companies that have participated in this study are all suppliers to the maritime industry. They are mainly producing equipment for carrying out mechanical operations and other equipment necessary for everyday ship operations (Helseth, Mellbye and Jakobsen, 2018) Some examples of what they deliver are cranes, winches, safety equipment, engines, thrusters, propellers, bridges, and so on. According to Helseth, Mellbye and Jakobsen (2018) the Norwegian production and sale of ship equipment generates revenues of 59 billion NOK and together they employed 18 000 people in 2017.

Maritime equipment suppliers are involved in several types of projects. The companies are mainly involved in projects concerning building of new vessels, maintenance of existing vessels or offshore installations. In projects where a new vessel is built, the involved parts are the maritime equipment suppliers, a ship designer, a shipyard, and the final customer. The final product could be a cruise ship, fishing vessel, service vessels, or exploration vessels, to name a few examples. Maritime equipment suppliers are also involved in maintaining existing vessels and several offer after sale service. They also deliver their products to the offshore oil and gas industry. For these projects, an intermediary company is often involved, and is responsible for ensuring that the proper specifications are followed on behalf of the end customer. This is illustrated in figure 12 together with our research focus, the maritime equipment suppliers. The arrows illustrate the flow of goods, while the flow of information flows both ways in the supply chain.

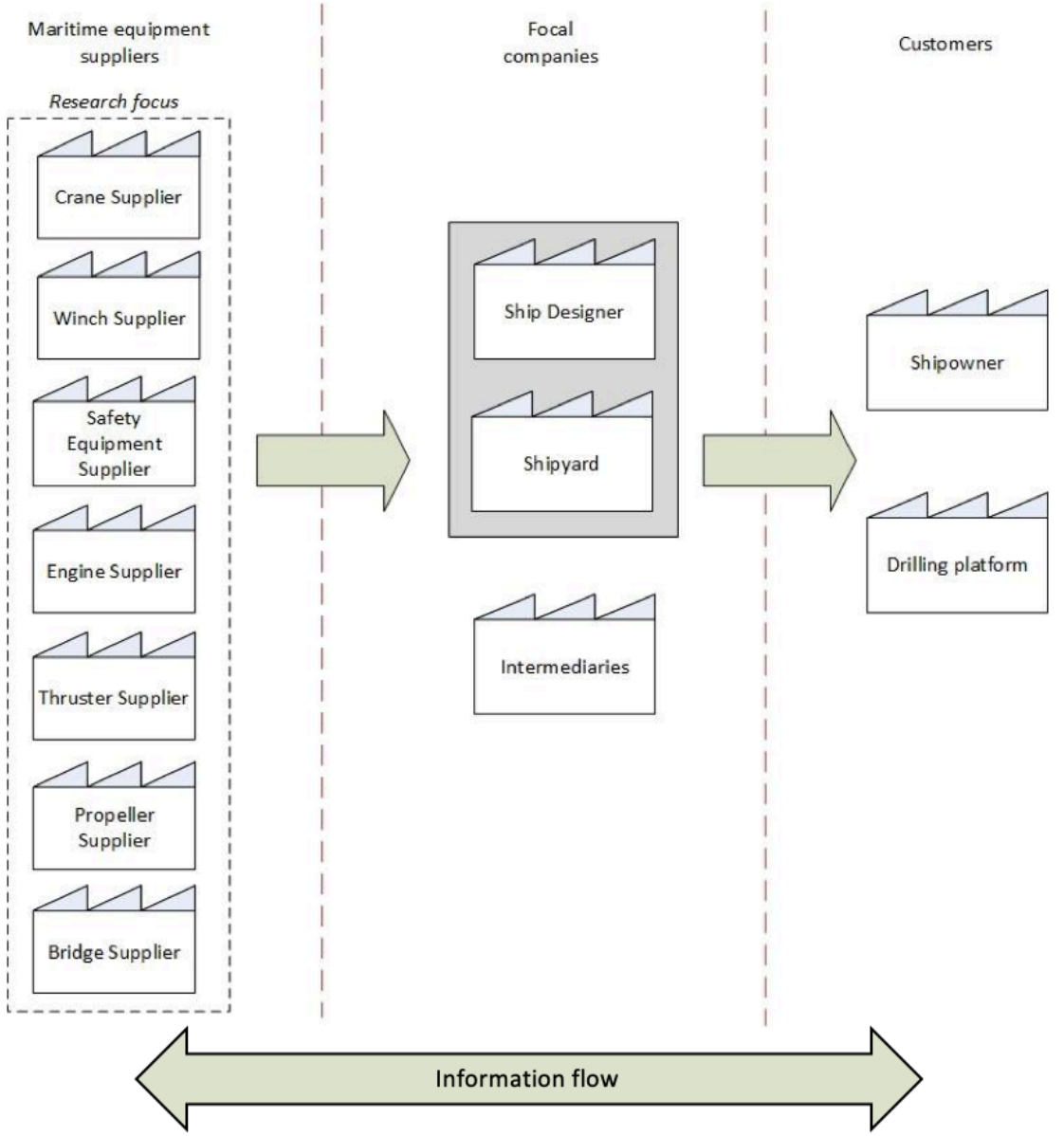

Figure 12: Supply chain for production of maritime goods. (Inspired by Mello, Strandhagen and Alfnes, 2015b)

4.2 Findings

As mentioned earlier, six in-depth interviews with equipment suppliers for the maritime industry were conducted. Furthermore, a questionnaire was sent out to 54 equipment suppliers in the maritime industry, 27 of these completed the survey. From both the interviews and questionnaire, it became evident that most of the companies delivered equipment to shipyards (new vessels) and ship owners (existing vessels), followed by oil industry, fishing industry and others. Figure 13 represents the respondents´ customers.

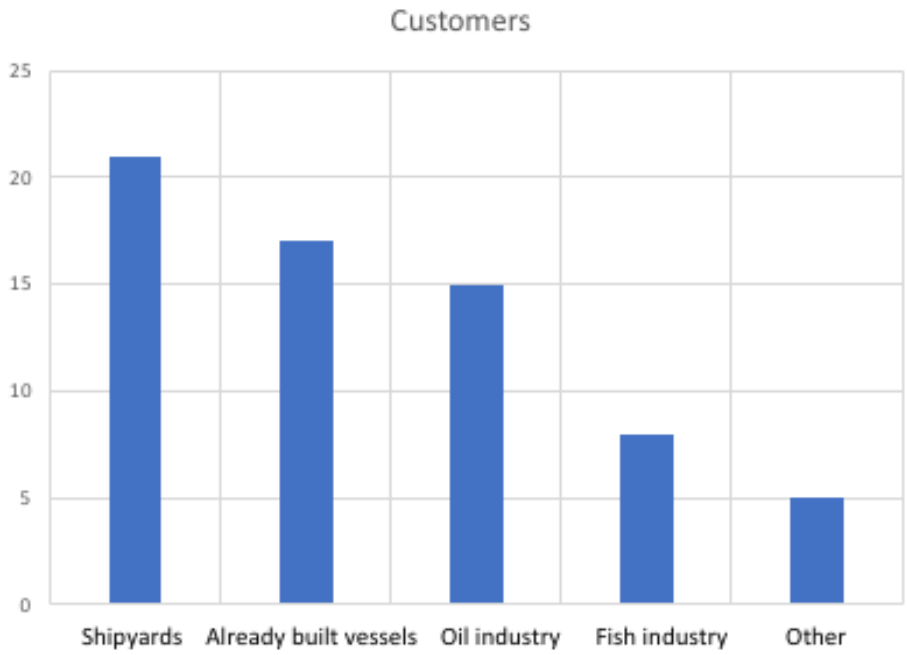

Figure 13: Customers

4.2.1 Structure of the supply chain

Through the interviews, insight into how the companies´ supply chains are structured and the process of delivering a product starting with customer request has been gained. Below, in figure 14, the process is illustrated.

Figure 14: Supply chain for the maritime equipment suppliers

The supply chain for the maritime equipment suppliers starts with a customer request or an inspection and visit at the site. This inspection could be with an intermediate, who is in charge of purchasing the equipment on behalf of the end customer or it could be the end customers themselves. The shipyards buy maritime equipment from the equipment suppliers on behalf of the end customer. Followed by an engineering phase in order to best adapt the

maritime equipment to the customer´s needs. The purpose of this engineering phase is to give a suggestion to the customer on how the product could look like and what features it could have.

Tendering is the next phase. The customer will decide if the presented outline and prospects cover their needs and expectations. If it does, a contract is signed between the customer and the equipment producer. Following, more engineering work is performed where the final product is customized for the customer. The firm will then purchase the needed goods for production. The maritime equipment will be produced in accordance with the drawings made in the engineering phase. The production could either take place locally at the site, be offshored or outsourced. Lastly, assembly and delivery are carried out.

For many companies, the phases in figure 14 are performed concurrently. Our findings show that engineering, purchasing and production are the phases that often are overlapping. From the interviews, it is experienced that engineering and purchasing were performed concurrently in order to reduce lead-time for items with long delivery time. More of the findings about CE will be presented later in this chapter.

4.2.2 Production strategies

During the interviews, the companies explained that they produced mostly based on customer's needs and requirements. From the questionnaire, it can be seen that 22 of the 27 companies´ design and engineer the product based on customer requirements. When they answered this question, they had the possibility to choose several answers. As some respondents ticked off several of the boxes, it seems that many companies produce different products, both customized and more standardized. This can be interpreted as the fact that companies want to retain a high degree of flexibility and the ability to respond to customers' exact needs. This is confirmed from the survey question about the advantage they gain from having the production strategy ETO. A total of 25 out of 27 answered that an advantage with ETO was that the customers get what they want.

Production strategy	Number
We design and engineer the product to the customer's need/requirements (ETO)	22
We have product design ready before the customer is involved, however, we produce after customer order (MTO)	17
We have design and components ready and assemble the product after customer order (ATO)	13
We produce to stock sell products from there (MTS)	3

Table 2: Production strategy of the different companies

The results from the questionnaire showed that there was a high number of companies that have product design ready before the customer is involved. From the in-depth interviews, several of the respondents alleged that they often reused design from earlier projects as a start before a customer order, especially if it was a customer they knew from earlier projects. Thereafter, changes were made to the design based on the customer requirements. Thus, this can be the reason for the high response for both ETO and MTO. Further, there are some answers that indicate a more standardized product. This study will go further into standardization later in the chapter.

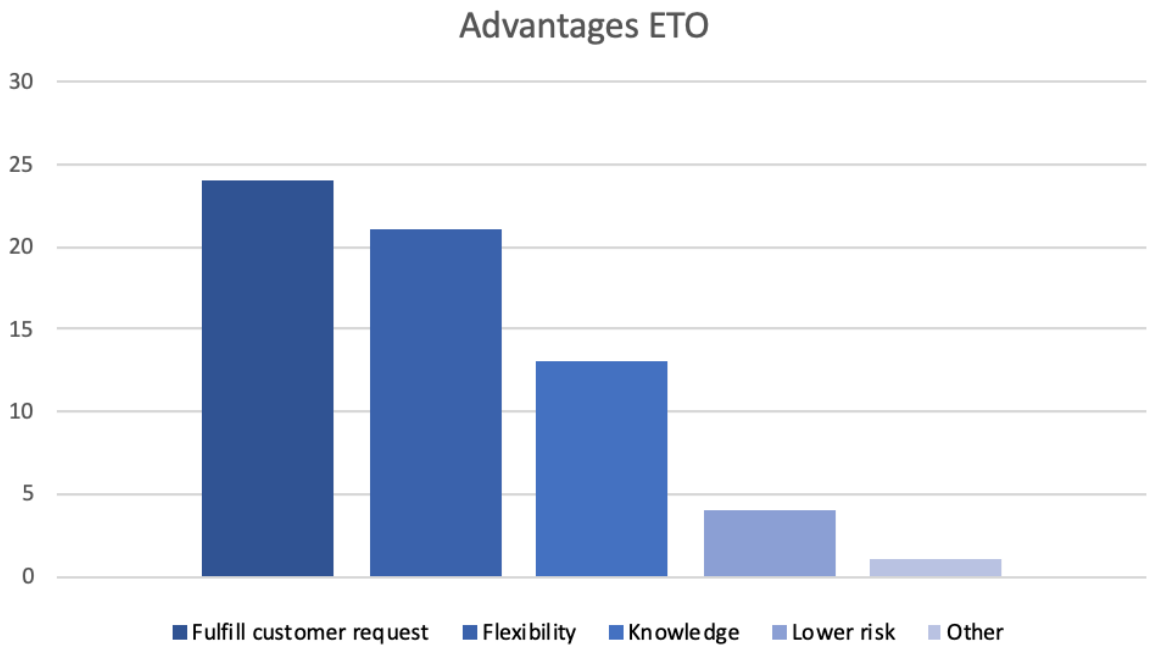

Figure 15: Advantages with ETO

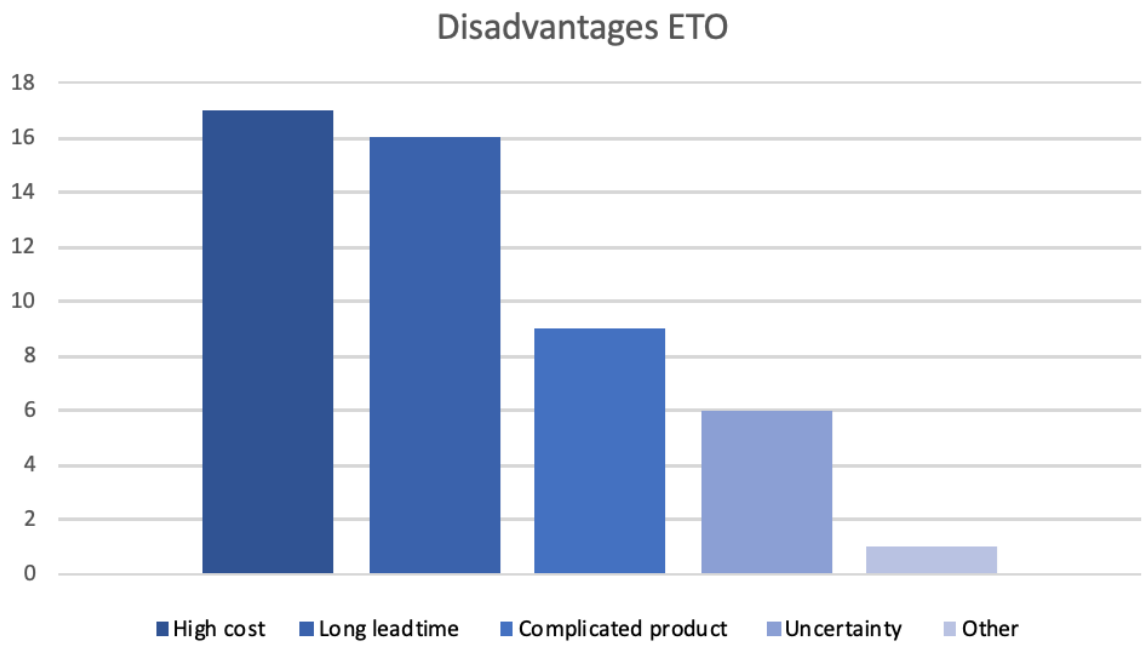

Figure 16: Disadvantages with ETO

The figures above show advantages and disadvantages with ETO. The majority of the respondents from the survey mention flexibility, and that the customer gets what they want as the main advantage. The disadvantages are mainly long lead-time and high costs for the end product. From the interviews, several respondents mentioned the advantage of expertise. Customers usually need the expertise from the suppliers to develop the product they need. It often occurs that the customer does not know exactly what they need until they have talked to the equipment suppliers. It is mentioned that customers often spend a long time internally trying to figure out what is optimal for the final product. One of the respondents said that customers usually has ideas for what they wanted from the project and made specifications for the product. However, when the equipment suppliers come for inspection, the whole concept and the customer ideas may be changed due to lack of knowledge from the customer side. Consequently, the customers could possibly save time and money by involving suppliers earlier in the product definition. On the other hand, there are also customers with a lot of knowledge, high expectations and often have many specific requirements.

Another advantage mentioned by some companies is that they do not have products stored, so everything is sold before it is purchased, therefore there is less risk connected to it. ETO products are typically of high cost, which is seen as a disadvantage by several of the respondents. It is difficult to compete on price, therefore, they mostly compete on quality and advanced technical expertise. Furthermore, another disadvantage mentioned is

unforeseen events and changes that often occur during a project, which may increase the lead-time. When the question about what each company see as their competitive advantage was asked, quality, service and knowledge was mentioned the most.

It was mentioned by several companies that they needed to have an ETO approach because of customer requirements, regulatory requirements, third party claims, and specifications to the location of the equipment. Equipment also needs to be approved by ISO standards and other requirements from the government to be used in maritime environments.

4.2.3 Changes in projects

Figure 17 shows how the respondents of the survey answered the questions regarding when customers could do changes during the project. The dotted lines in figure 17 are for each respondent, the red bold line shows the average. The Y-axis shows from 1 – no changes to 6 – all possible changes. As can be seen in the figure, most changes are done early in the process with a declining trend in later phases. The interviews showed much of the same results. The customers usually had the opportunity to do changes in late phases. However, it would increase cost and lead-time of the project. Further it is mentioned that it depends which type of change it is. Small changes are easier to implement in late phases.

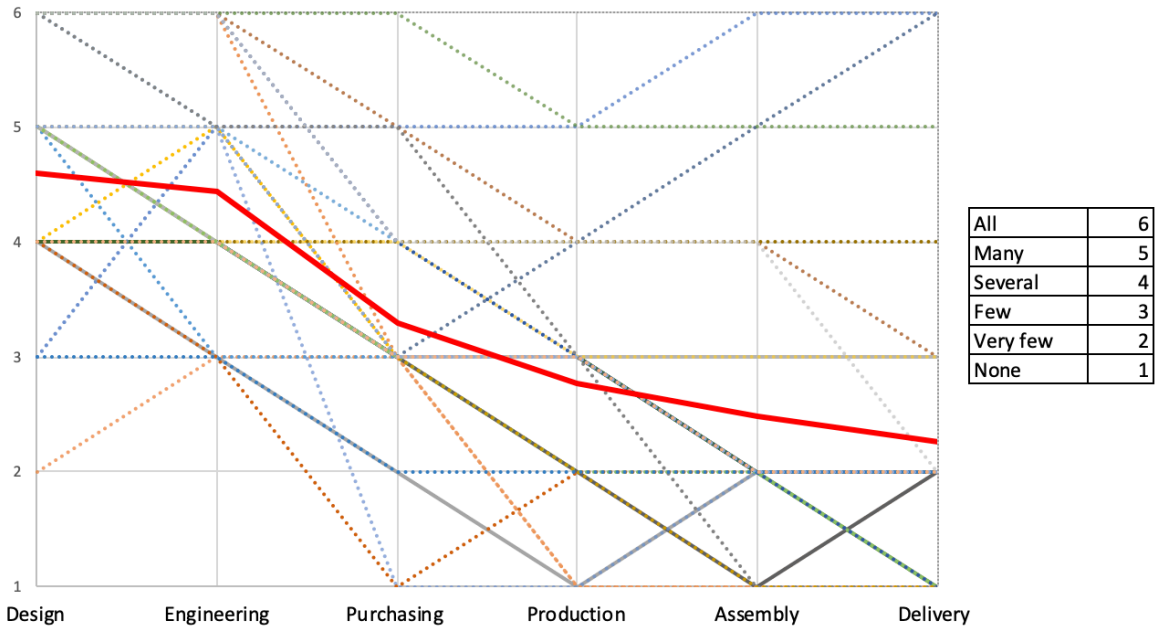

Figure 17: Changes in project

A question regarding which problems that can occur during a project was asked. From the figure below, it is illustrated that challenges with changes turns out to be the biggest problem, followed by longer lead-time than expected and communication. Other problems like faulty drawings, unclear contract, and unexpected challenges with bankruptcy with supplier were also mentioned in the interviews. The challenges connected to communication are mostly because of cultural differences and supplier power.

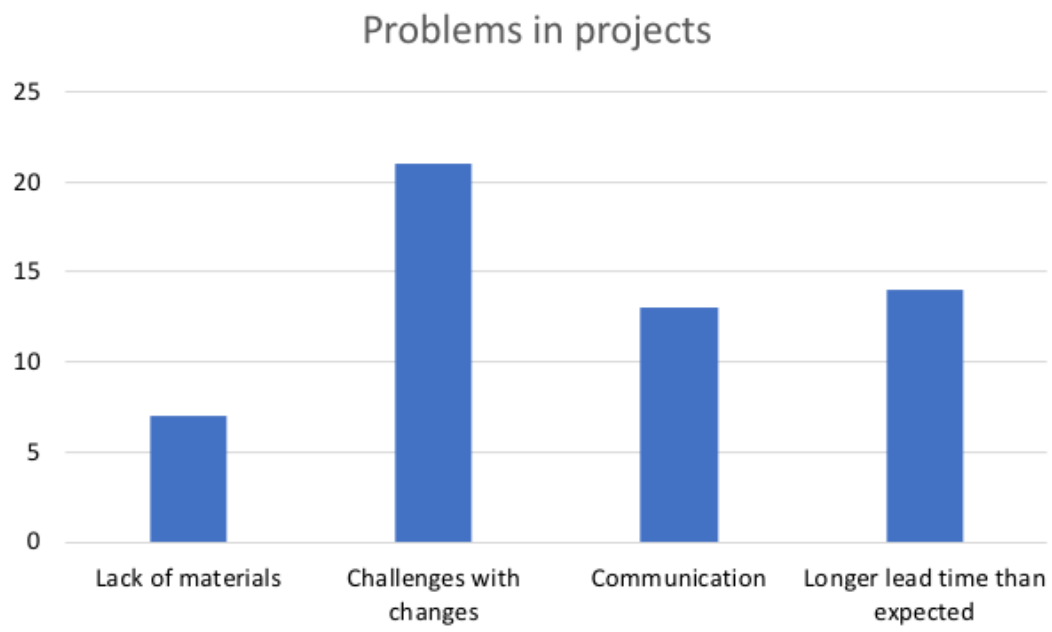

Figure 18: Problems in project

Some of the companies that were interviewed mentioned that it was especially challenging with changes when there were foreign suppliers involved. Suppliers from Asia want things to be clarified in advance and do not like changes along the way. Thus, they are often less flexible, which is mentioned as a problem since it is an important factor for many of the Norwegian maritime equipment suppliers and their customers. Norwegian customers and suppliers are more open to solve problems along the way.

We also looked at the outsourcing and offshoring strategies applied by the case companies.

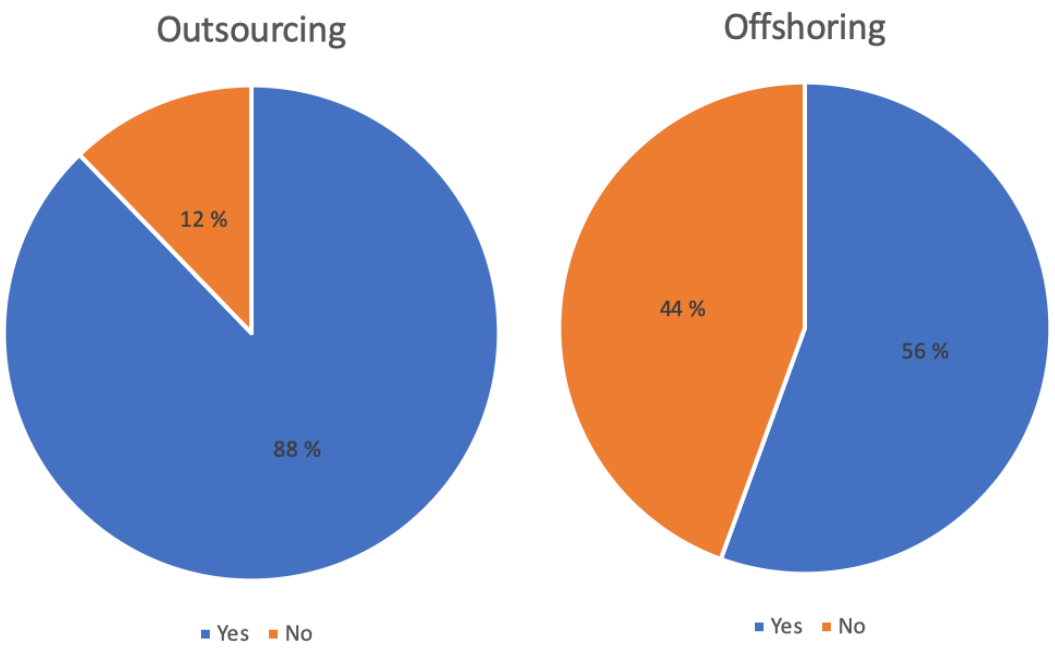

Figure 19: Outsourcing and offshoring of activities

Figure 19 highlight the result from the survey when it comes to outsourcing and offshoring activities in a project. Only four out of all respondents from the survey and interviews had all phases of their projects in-house. The advantages mentioned by having all phases in-house are control, easy dialogue and quick response, flexibility and adaptability, shorter lead-time, quality control, and proximity to production. The main disadvantage by doing everything in Norway is the cost connected to it. Conversely, cost is mentioned as the main advantage when outsourcing activities. The disadvantages mentioned by the respondents regarding outsourcing, are problems with language and cultural differences, customs, regulations abroad, longer in lead-time and difficult to follow-up the real status of the production.

As one can see from figure 18, communication is also a problem in projects. From our interviews we got to know that communication becomes a problem when several changes are performed. For the companies that have outsourced production to other countries there was a challenge ensuring that the supplier was updated on the latest changes. Since the Norwegian companies have a high level of flexibility and are open to changes throughout the project, it is challenging to ensure that all parts involved get the right information at the

right time. From the interviews, it was discovered that the companies with outsourced production had a control unit in that country to ensure oversight of production. This can be understood as the fact that companies are willing to use money and resources to ensure good quality and control over production.

4.2.4 Standardization and modularization

One of the interview objects mentioned that there was a change from customized to more standard products after the financial crisis. Both customers and suppliers wanted to do things as cost efficient as possible, thus, the customers reduced their requirements. As the times were getting better, customers had several more requirements and greater will to pay again, hence, there has been an increase in demand for customized products. One respondent also said that they had ETO because the customers' requests for customized products. Conversely, the company would value a lower degree of complexity as it would be beneficial for both cost and lead-time of a project.

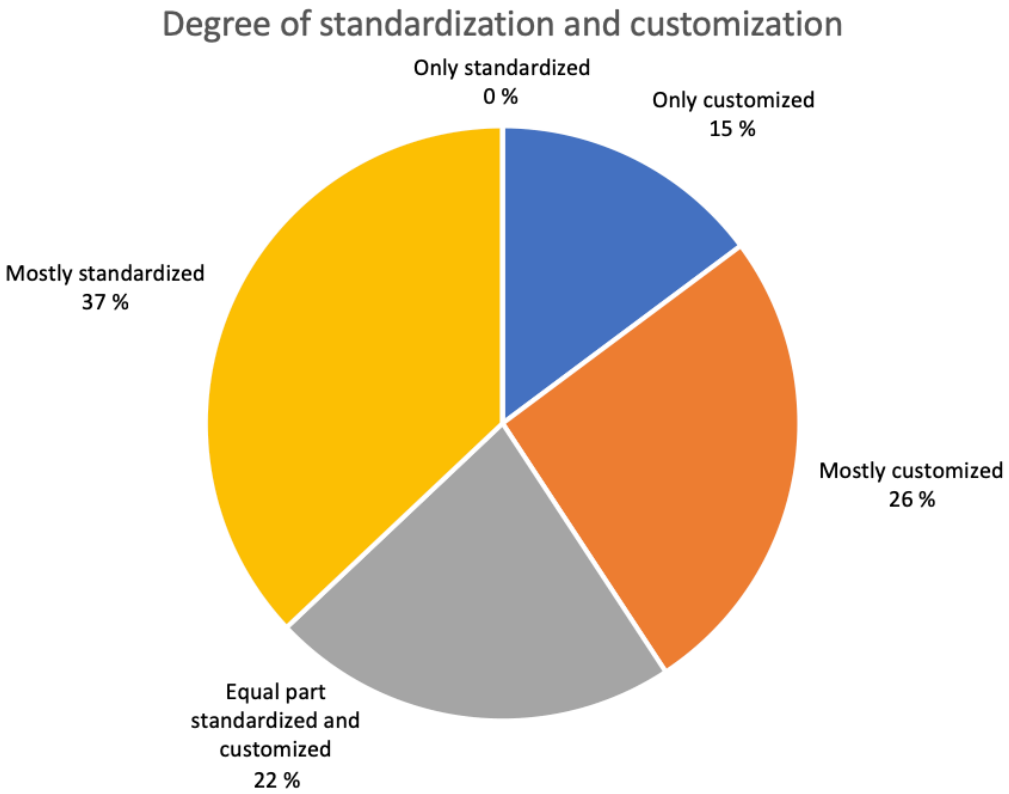

Figure 20: Degree of standardization and customization

As can be seen from the figure 20, the answers from the survey show that case companies offered a mix of standardized and customized equipment. However, several of those who

said they offered mostly standardized products also said they used an ETO production strategy. On the other hand, there is 41% of the respondents who mostly or only offer customized products.

From the interviews, one of the findings were that there were mostly customized products that were demanded. Several of the companies designed the product to specific customer requirements. However, some companies additionally offered more standardized products. Overall, some products were highly complex, while some were quite simple and possible to deliver from warehouse. Most of the companies that were interviewed had looked at the possibility to increase their degree of standardization and modularization in order to decrease costs and lead-time. One of the respondents produced winches based on speculations because of long lead-time for some of the components. They could see that their competitors often had problems delivering within 24 weeks to 1 year. The risk of starting to produce before customer order is usually high, however, they saw the benefits and competitive advantage with fast delivery as strong since it was giving them an increase in profit. Even if the production has started, outfitting was usually different from customer to customer. Another company that was interviewed sold a lot of standardized solutions when they produced to drilling platforms. They offered standard variants with modularity options. Furthermore, they sold a substantial amount of the products with a high degree of standardization, the execution was managed by four to five persons, thus it resulted in a good turnover with relatively low effort. Several respondents had modular options where they put together different solutions based on earlier projects that would suit most of the customer demand. Some respondents did not have modular options because of the product type they offered did not allow it. Furthermore, some could see themselves providing it or worked against providing it.

Several of the companies interviewed reused design with small adjustments. Reuse of design was mentioned as a possibility to lower the time and cost associated to design and engineering activities. Hence, a possibility to decrease the total lead-time of the project.

It was also mentioned by several of the companies interviewed that a more standardized product would make it easier to negotiate with suppliers and get better conditions as it would allow the company to buy in bigger quantities. Further, it was easier to have suppliers in readiness to deliver faster if needed. Standardization and modularization were mentioned as

a more competitive strategy, although it should not affect flexibility and the opportunity to meet customer demands. Several of the companies explained that standardization could possibly slow down development of new products and innovation. Several of the interviewee mention a balance of customized and standardized products as important for the Norwegian maritime environment.

4.2.5 Concurrent Engineering

Answers from both survey and interviews highlight that most of the respondents use a CE approach. Design, engineering, purchasing, and production are those phases of the project that usually are done concurrently by the respondents. Figure 21 and 22 show how the respondents from the survey answered the question about advantages and disadvantages with CE.

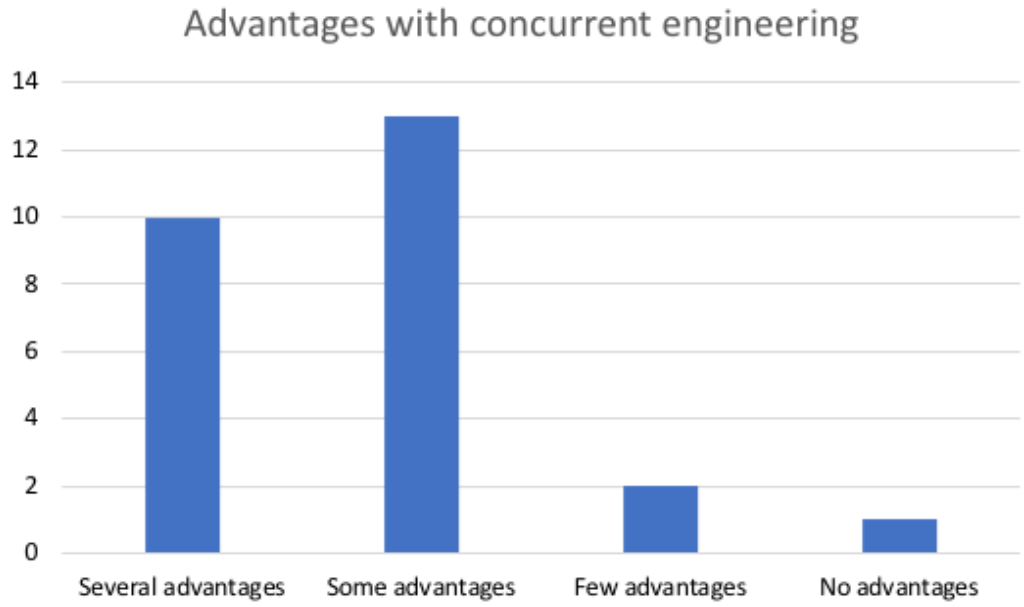

Figure 21: Advantages with concurrent engineering

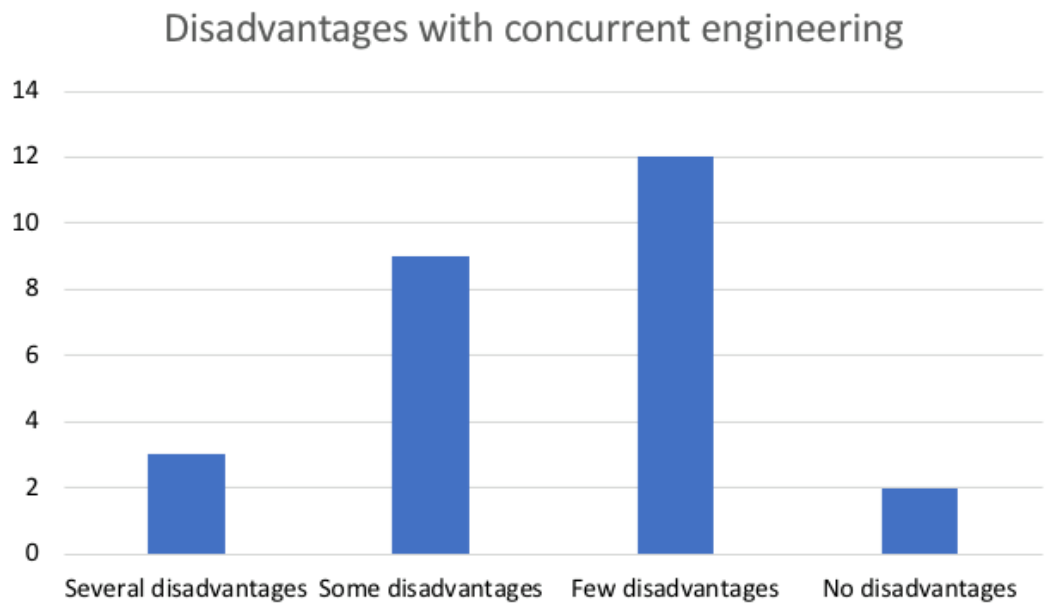

Figure 22: Disadvantages with concurrent engineering

The interviews gave some specific advantages and disadvantages. Several of the companies said that concurrent engineering gave them the opportunity to decrease lead-time of the project. Another advantage that is mentioned with having CE and purchasing is that it allows the companies to purchase critical components early in the project.

On the other hand, overlapping of engineering and purchasing is mentioned as a disadvantage by several respondents because it could cause delays if long lead items were not finished in engineering. Furthermore, if drawings were not finished, it could cause delay of production. Another disadvantage that was mentioned is that cost control is difficult when design is not ready before purchasing. It was also stated by one company that it is easier to use low cost producers if everything is decided before production.

Two of the respondents from the survey did not have CE. One of the companies was not able to implement CE because of strict requirements connected to positioning of components and welding engineering. This company works in a more sequential way. One problem they had with the sequential approach was if a delay of the design phase occurs, it results in late clarification from the customer. Further, it affected purchasing of components which led to delays of production.

4.3 Summary

In this chapter, the case has been presented and an overview of the supply chain for the maritime equipment suppliers has been given. The companies involved in the study delivers customized equipment to shipyards, oil, gas, and fishing industry. Furthermore, the findings highlight that many have the possibility to standardize and provide modular options. However, the firms have stated that standardization may prevent innovation and decreased flexibility. Further, advantages and disadvantages the respondents sees with ETO have been identified. We saw that customers are allowed to do most changes in the early phases of the project, with a downward sloping towards the late phases with small changes. From this it could also be observed that there were challenges connected to changes. Most of the companies use CE, and some advantages and disadvantages were identified. In addition, most of the respondents outsourced or offshored their production and it could be seen that this brought both advantages and challenges to the companies.

In the following chapter, empirical findings will be discussed against relevant theory.

5.0 Discussion

In this chapter, the findings will be discussed and analyzed up against the theoretical framework. This thesis aims to find out how ETO is influencing the supply chain and if such production strategy is a competitive advantage. The case study has given insight into both challenges and advantages to the production strategy ETO, and into how customers are involved in a project. An answer to the research question will now follow. First, we elaborate how an ETO supply chains are affected by different factors. Second, we discuss how customer involvement in ETO projects affect the processes performed by the company.

5.1 RQ 1: What factors affects an ETO supply chain for maritime equipment suppliers?

The intention of this section is to identify some of the factors influencing the maritime equipment suppliers. First, a description on different types of ETO will be presented since it is relevant to show that ETO companies can operate differently and have different core competencies. Thereafter, it will be elaborated on changes, CE, modularization, standardization, and how placement of production can influence decisions and behaviour.

5.1.1 Different types of ETO

The findings illustrate that most ETO companies´ production is based on customer needs and requirements, as they want to retain a high degree of flexibility. However, the companies that have been research objectives in this study produce in different ways. Some of the companies outsource parts of the project, others have all phases in-house. Thus, respondents have different types of ETO. Hicks, McGovern and Earl (2001) observed four types of ETO companies. *Type I* companies have their core competencies in design, production, assembly, and project management that have high product and process knowledge. Further, Hicks, McGovern and Earl (2001) mentioned that *type I* companies have an incentive to use modular design because of low value or irregular purchases and increases supplier power. Most of the respondents have their core competencies in design, production, assembly, and project management. Several of the respondents mentioned that there was easier to negotiate with suppliers if they would have more standardization or modular options. *Type II* companies have their core competencies in design, assembly, and project management. These companies keep production of critical items in-house while they outsource non-critical items, and they are reliant on a good relationship with their suppliers in order to reduce lead-time (Hicks, McGovern and Earl, 2001).

Most of the respondents count as *type I* or *type II* companies. The respondents that count as *type I* companies, they all had production in-house to ensure full control, and they had the expertise to carry out the job. The reason that some respondents count as *type II* companies, is because they outsourced production of non-critical items. Production of critical items and all other phases of the project were kept in-house to retain control. Several companies have production of critical components in-house, as well as outsourcing production of non-critical components in order to decrease costs. In addition, they are also reliant on a good relationship with their suppliers to lower lead-time.

Furthermore, there are respondents that count as *type III* companies. These companies mentioned that they already offered some standard products. Which implies that there are already companies in the industry that offer standard options for their products and possibility that several companies can follow. None of the companies in this study is of *type IV* which is companies doing consultancy.

5.1.2 Changes

ETO requires a high degree of customization and variation, which means that there is uncertainty connected to design, engineering, drawings, and technical details. Engineering and design changes are difficult to avoid and are challenging in ETO projects (Iakymenko et al., 2018). Product changes after production starts are a challenge and can affect both the cost and the lead-time of the project (Haji-Kazemi et al., 2015). The figure below shows that there is a declining trend in project changes for our respondents. Most changes can be done early in the project, fewer can be made in later phases, which is the optimal trend in relation to costs and lead-time for the studied companies. However, the findings in the previous chapter showed that there were challenges connected to changes in a project and that there were issues with longer lead-time than expected.

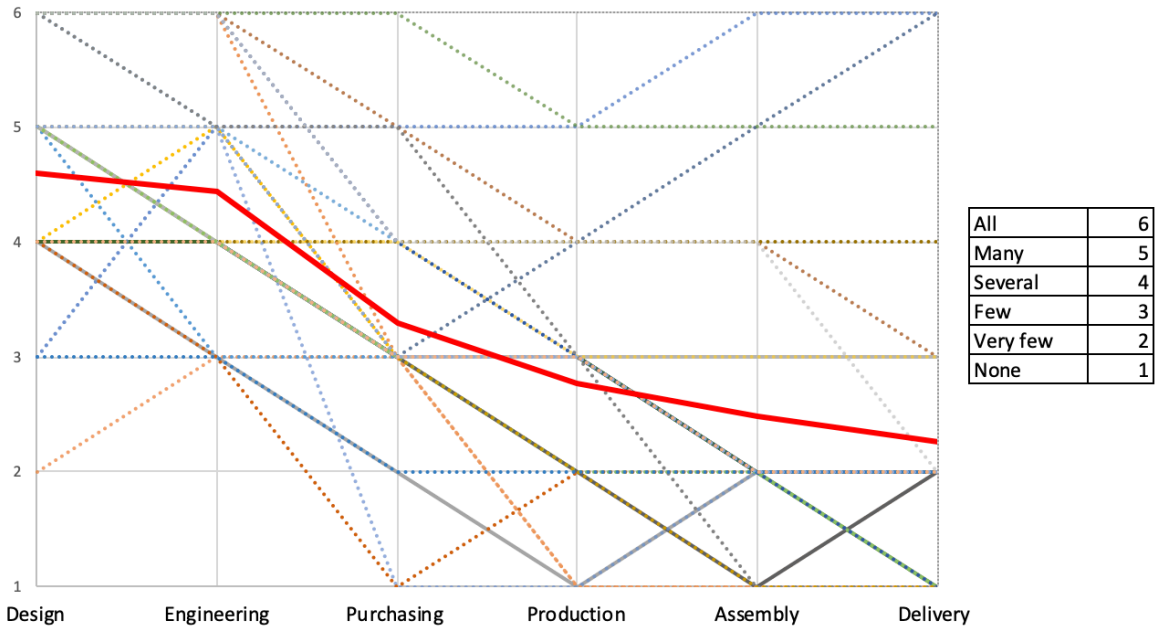

Figure 23: Changes in project

Figure 24 depicts that changes during the project challenges the production regardless of the chosen approach: outsourced, offshored and in-house. So, it does not seem that location of production is the reason, there are other factors that contributes to the challenges.

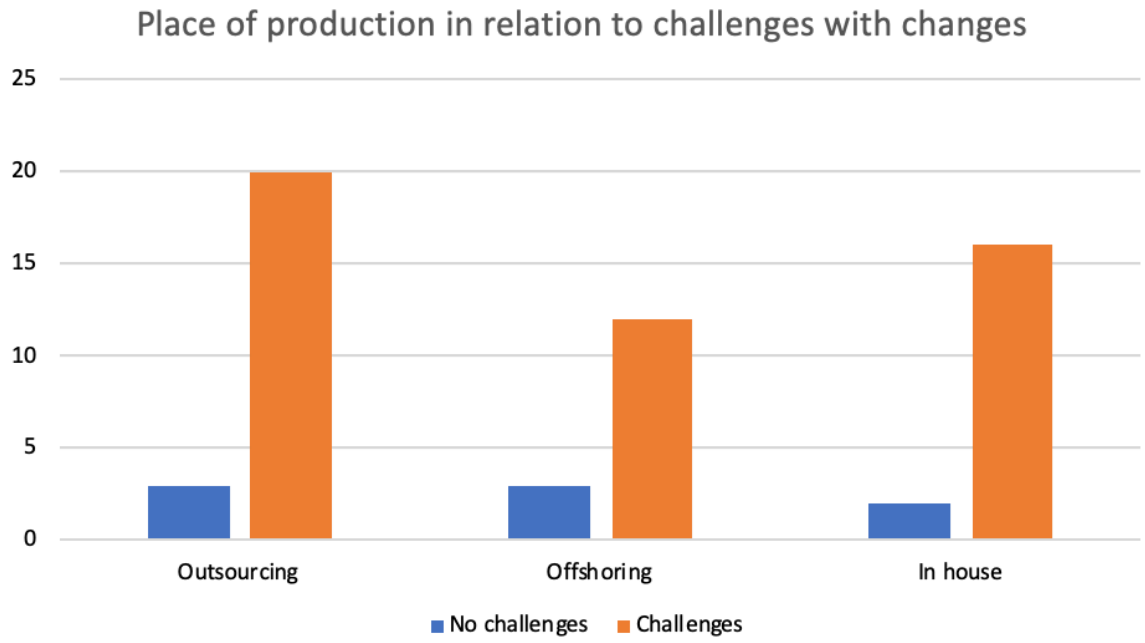

Figure 24: Place of production in relation to challenges with changes

It is stated by Haji-Kazemi et al. (2015) that CE makes it difficult to identify potential problems early in the process. Further, he mentions EW that indicate if a project may fail or need urgent changes are common. As most of the respondents had CE, this could be a reason for problems in relation to changes in a project. As phases are done concurrently, it can be difficult to locate the problems early enough to avoid them.

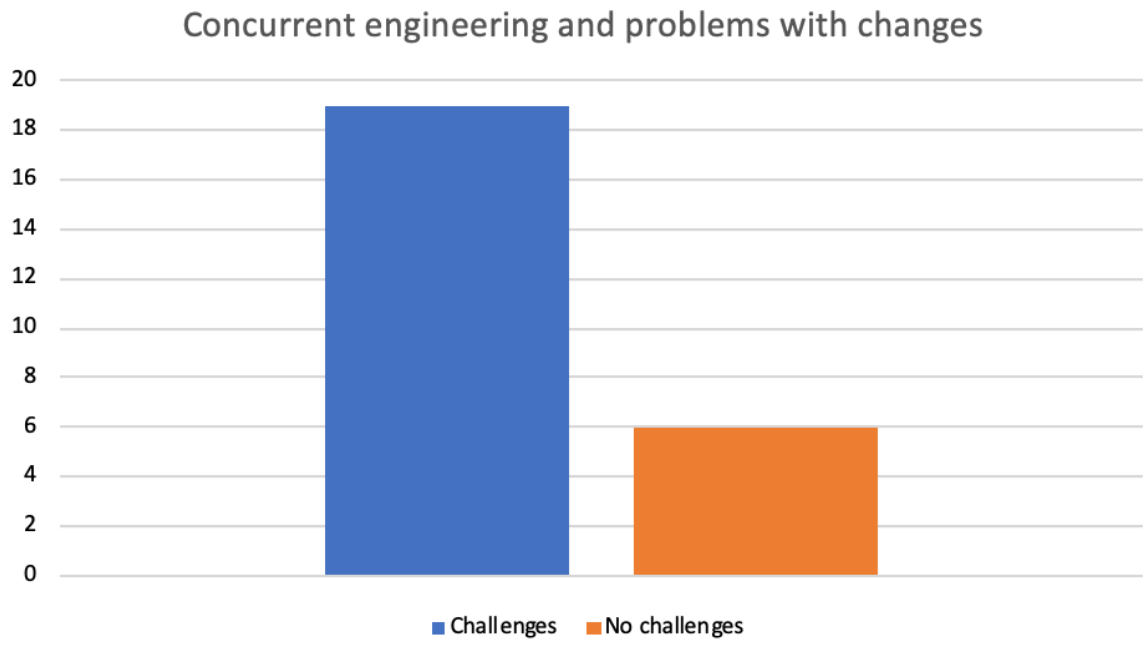

Figure 25: Concurrent engineering and problems with changes

Figure 25 illustrates those who have CE and if they have challenges regarding changes in a project. A total of 19 out of 25 respondents that use CE also have problems regarding changes, six respondents does not have problems. A solution could possibly be to finish early phases like product design, drawings, and technical details before purchasing. Several respondents performed design, engineering, purchasing, and production concurrently. If design, drawings, and technical details were specified before purchasing, the maritime equipment suppliers could possibly avoid big changes and have a better cost- and time control.

CE is mentioned as one of the strategies that can improve performance in ETO projects (Ahmad et al., 2016). As mentioned by Anumba and Evbuomwan (1997), CE can ensure a competitive advantage in terms of price, quality, durability, and be more responsive to changes. From the findings, it can be observed that price and durability were a big advantage.

However, some respondents also experienced problems with CE. Pieroni and Naveiro (2006) state that CE aims to do the job right the first time since changes become more expensive when they occur later in a project. From what can be extracted from the findings, it became evident that it was possible to do changes in later phases of the project. Thus, CE could cause a higher cost and longer lead-time of the project as phases need to be re-done. Hicks, McGovern and Earl (2001) argue that overlapping engineering and production activities are seen as one of the main sources of uncertainty since engineering work is not finalized before the production takes place.

A suggestion for the maritime equipment suppliers, to have successful CE and avoid large changes in late phases, could be early involvement in the design phase. Some respondents mentioned that they wanted to be earlier involved in the process as they had the expertise many customers were missing. It is important that the customer also involve their suppliers early to avoid unnecessarily time and cost at the start of the project and throughout.

Several respondents had design ready before customer involvement with the possibility to do adjustments later, which can cause several changes throughout a project compared to earlier involvement. With early involvement of customers, teams from design, engineering, purchasing and production can find proper solutions at an early stage and possibly avoid big changes in later phases. Therefore, the optimal solution for the maritime equipment suppliers could be to finish up the product design before engineering, purchasing and production and focus on involving customers at design phase. As can be observed in figure 7 in the theory chapter, early warnings about problems and changes will often be located at the design phase. We do not mean that CE and the flexibility that changes enable should be avoided, it is meant as a solution to minimize number of big changes throughout a project with more information sharing and interaction with customers early. When design is accomplished, further phases can proceed concurrently.

Further, communication and coordination are an important part for CE to be successful (Mello, Strandhagen and Alfnes, 2015; and Bhuiyan, Thomson and Gerwin, 2006). It is also mentioned that challenges with coordination increases when interdependent activities are performed by different partners (Mello, Strandhagen and Alfnes, 2015). The findings demonstrated that there were challenges connected to communication in projects, especially

because of cultural differences and supplier power. Figure 26 indicates that there are more challenges with communication when production is outsourced compared to in-house.

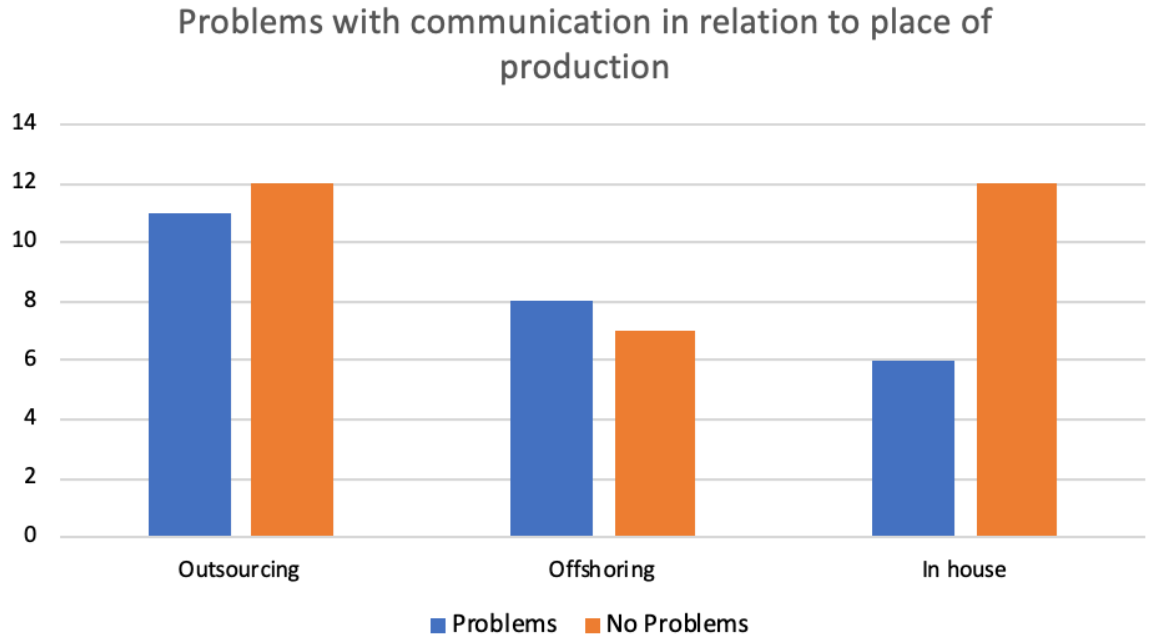

Figure 26: Problems with communication in relation to place of production

Based on the theory of CE, it might be easier for the Norwegian maritime equipment suppliers to perform successful CE by having all phases in-house. However, for many companies, CE is necessary to retain because of the mentioned advantages. Therefore, it is necessary for the maritime equipment suppliers to ensure proper communication and coordination with foreign suppliers to avoid problems.

5.1.3 Standardization and modularization

The findings indicate that there is a positivity regarding standardization and modularity in the industry. Several respondents already offered standardized solutions and modular options. Standardization of components is an option to reduce product complexity (Kampker et al., 2014). While modularity can reduce range of components and at the same time offer a wider assortment of end products (Duray, 2002). Further, it enables parts of the product to be produced in higher volumes, and uniqueness can be achieved through combinations of modules. However, this implies that the companies would move towards an MTO supply chain.

As presented in the findings, several companies delivered both standardized and customized products to their customers. From the interviews, it can be seen that the companies in some projects reused design from previous projects in some of the newer projects, because of their knowledge and their narrow product range, they produced quite similar products. Our understanding is that many companies does not have standardized products, instead they reuse design and make small adjustments from previous projects that leads to a small diversity of delivered products. One of the respondents stated that the product they sold to the customer as highly customized, was in their view not unique from previous deliveries. To the customer, they promoted it as a totally unique product, while for them it is well-known.

As stated in Dekkers (2006), reduced engineering work will be possible if the product design consists of standard modules, basic modules, and optional modules. These modules can be mixed to create new variants of the product and the customer can create the product they demand (Fixson, 2006). Reduced time and cost on design and engineering work are also possible by tailored customization, as the customization goes back to fabrication, yet not to design phase. The findings showed us that several companies used tailored customization where design is reused and adjusted based on customer requirements. In projects where innovation takes place and creates new products, they have a pure customization, which may result in tailored customization for later customers. From this research it can be observed that they rarely make use of pure customization.

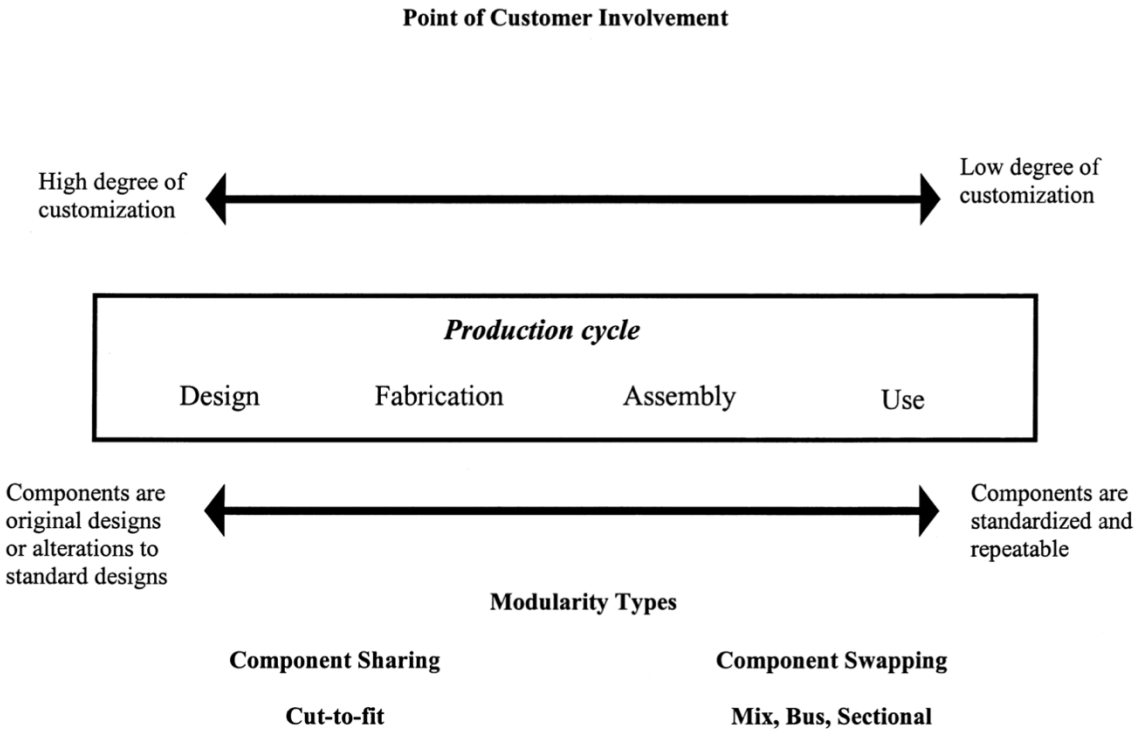

Figure 27: Customer involvement and moduarity in the production cycle (Source: Duray et al., 2000)

Figure 27 illustrates that there are different degrees of modularity. For the maritime equipment industry, each type of modularity would depend on customer requirements as well as on which type of product they are offering. If they offer products with a lower degree of customization, it would be more beneficial to be on the right side with components that are standardized and repeatable. Conversely, they should be more on the left side with component sharing and cut-to-fit if the product is customized. For the maritime equipment suppliers, it is important to allow customization for the customers. Therefore, component sharing, and cut-to-fit modularity would probably be the best suited solution. Component sharing allows the customers to uniquely design the product around a base unit of components. Cut-to-fit allows unique dimensions to the product, for instance length or height, before the module is combined with other modules.

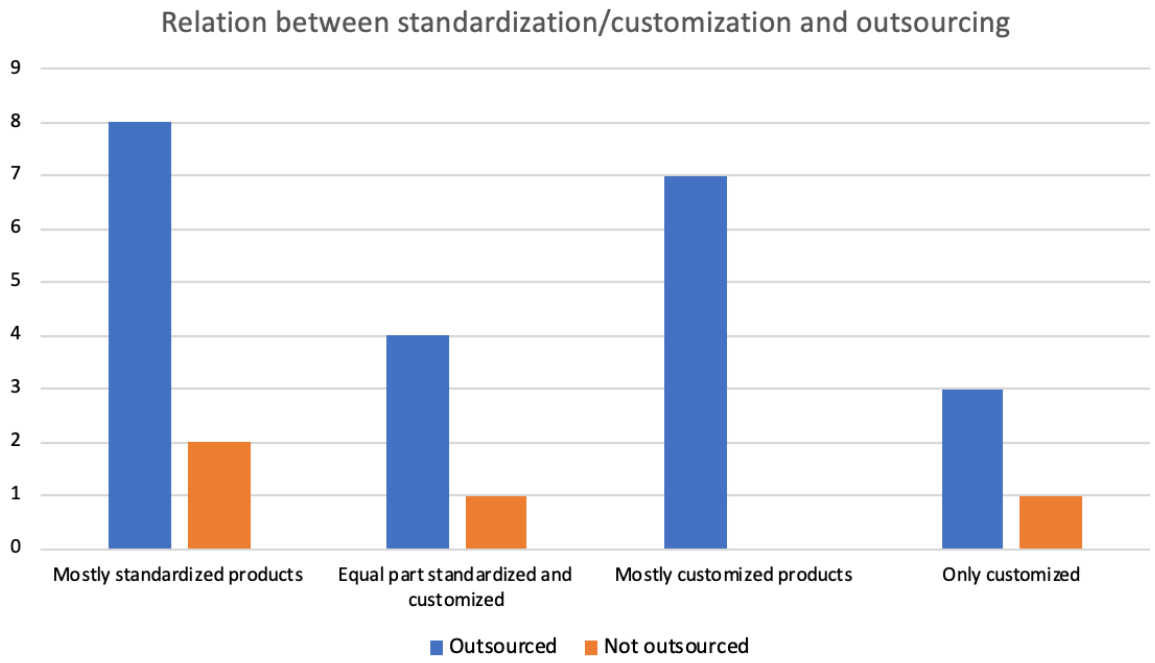

Figure 28: Relation between standardization/customization and outsourcing

In figure 28, the blue column shows those who outsource, while the orange column shows those who do not outsource any of the project phases. It illustrates that there is a high degree of outsourcing with both standardized and customized products. Customized products are quite complex, which can lead to the occurrence of more problems, especially when outsourcing. This is because quality control and communication seem to be more difficult when having production at an external supplier. Changes can also make the relationship between the case companies and their suppliers more difficult, as mentioned earlier. However, they may also maintain competitiveness as they gain a combination of local and global knowledge. On the other hand, it may be beneficial for the maritime equipment suppliers to outsource standardized product as they can benefit from economies of scale. Standardized products have a lower degree of complexity, and they have fewer changes throughout the project. Consequently, standardized products are more suited to outsource.

Mello (2015) mentions that a combination of modular and customized components provides a great flexibility to meet individual requirements in this production strategy. Based on theory and findings, it seems like modular options would be an appropriate strategy for the maritime equipment suppliers. With modular options, it is possible to maintain a great variety of products simultaneously as lead-time and cost can be reduced. Flexibility and the fact that the customers get what they want is mentioned as advantages with ETO. Therefore,

purely standardization will not be beneficial for the maritime equipment suppliers, as they would lose their competitiveness. Modularity will still allow customization and flexibility to a certain degree.

5.2 RQ 2: How is customer involvement affecting the processes in the project?

The customers of the maritime equipment suppliers are early involved in the process, and to some extent, the customer is involved in all processes throughout the project. The reasoning for this, and one of the ETO characteristics, is that the production process is driven by customer orders (Carvalho, Oliveria and Scavarda, 2015) and the entire project is performed based on a specific customer order (van Weele, 2018). In figure 29, the supply chain for the maritime equipment suppliers with the decoupling points is illustrated.

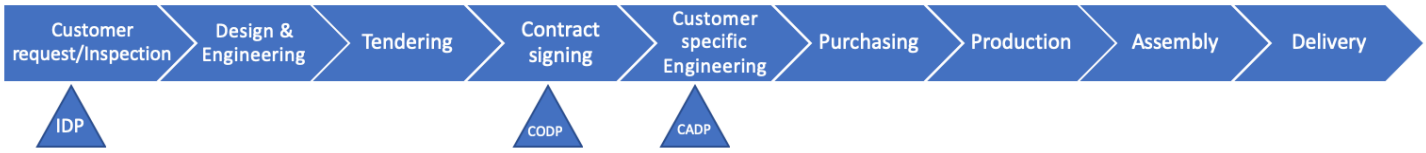

Figure 29: Supply chain for the maritime equipment suppliers with DP

The first phase taking place in the supply chain is the IDP which is situated within the phase customer request or inspection. In this research, it can be observed that most of the respondents´ customers are involved at the customer request/inspection phase. At this phase, forecasts are conveyed into actual demand and request from customers. The IDP is placed as far upstream the supply chain as possible, meaning that the companies use limited resources for speculating and forecasting. Design, engineering, and tendering follows, these phases are conducted on the basis of the information gained with the customer request or the inspection team. The design, engineering, and tendering phases are performed in order to secure order winning proposition, the engineering continues after the contract is signed. From the survey, one can see that many of the companies have completed product design before the customer is involved. This implies that they only perform customer specific engineering after the contract is signed. However, some of the companies completes the design of the product in collaboration with the customer.

The CODP is placed at the contract signing phase. At this point in the process, the customer commits to purchasing the product and the contract can be viewed as a purchase order of the

product. Thus, the product is linked to a specific customer order. The contract signing phase is followed by customer specific engineering. In accordance with the thesis´ theory, the customer in an ETO project is early involved in the process of designing and developing the product, and none of the specific production activities are started before a specific customer order is confirmed. The CADP is placed at the customer specific engineering phase since this is where the product is customized to the specific customer´s requests. The customization could involve adjustments of previous design or a total new design.

The decoupling points shown in figure 29, are the minimum of decoupling points that take place in an ETO supply chain. All of the companies involved in this study allowed changes, which increase the number of CADP. Figure 30 shows several customer changes throughout a project. Therefore, CADP is placed at all phases after contract signing. This will vary from project to project based on the number of changes and may be fewer.

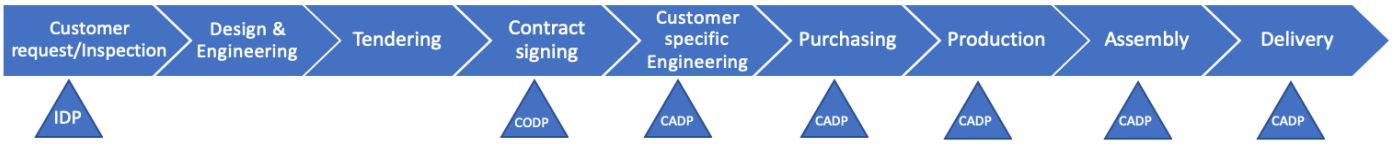

Figure 30: Supply chain for the maritime equipment suppliers with several changes

As mentioned by Hicks, McGovern and Earl (2001) this situation could be dependent on supplier- and customer power. Due to low value or irregular purchases, supplier power increases. If there are few suppliers offering the desired product, the supplier has the power. Thus, customers would need to be more open for the supplier's solutions. Conversely, if many suppliers offer the same product and there is little activity on the market, the suppliers will need to do as the customer demand. If the power is at the supplier side, figure 29 would represent the situation. On the other hand, figure 30 would represent the situation were customer has the power.

The companies state that they would like to be involved with the customers at an earlier stage. According to the interviews, this is because of the knowledge and the complexity of the products. The customers will, in some cases, start their purchasing process and figure out exactly what they want and their specifications before they involve the supplier. In these cases, the maritime equipment suppliers' desires to be involved at an earlier stage as the customer does not always have the proper knowledge about products and what solutions the

product could offer. They believe that if they had been involved at an earlier stage, they could have saved the customer resources spent.

By having an ETO supply chain the companies are facing the challenge of undertaking order driven design and engineering activities from impatient customers who have last minute request for changes (Wilner, Gosling and Schönsleben, 2016). The interviews and survey on this study reveal that the companies allow customers to make changes throughout the project. How many changes they can request, which processes they can request changes in, and how extensive changes they can request are slightly different from company to company. However, they all state that changes can be made to the product as long as the customer is willing to pay for these changes. The companies themselves explain that it is possible to implement most of the desired changes, however it is the customer that have to decide if it is crucial to execute the changes.

The respondents state that they can implement all the changes the customers want. However, it is the customer who has to pay for changes that happen after the engineering phase, and after the drawings are completed, and it is likely that the total lead-time for the project will increase and the product could become more expensive. The supplier desires to not have any extensive changes performed at later phases in the project. Late changes could increase uncertainty for the project and could lead to a high level of rework needed, which would mean that they need to perform a process for a second time or more. EW are also important to consider, as this could give signals as to whether the project is feasible or not. The objective of EW is to identify problems associated with a project and potentially avoid major changes, extra costs, and longer lead-times.

From the respondents´ perspective, it is an advantage that they do not start any production or investments before a customer has committed to buy the product. They never, or rarely, start the production of products before a customer is involved. On the other hand, it has a negative impact on lead-time which could be increased. Further, they could have an advantage with preparatory activities to reduce the lead-time of finished products. If the customer needs the product faster, it is possible that he will favour another supplier with shorter lead-time. However, this makes the production of highly customized products nearly impossible and is more feasible for standardized products.

Communication is also important to consider when working with customers, and when developing products in close collaboration with customers. It is important to ensure that the right information is presented and interpreted correctly. As explained in the theory chapter, it is important for project teams to manage communication the right way. If the project team fails to do so, the time spent on developing plans and controls will be wasted since the right information has not reached the right people, or it has been ignored or misunderstood (Rajhans, 2018). Ensuring proper communication with the customer will make it easier for the project to be performed with less challenges. It will also help securing stakeholders interest with the proper flow of communication.

5.3 Recommendations

Important findings from the research is highlighted in the following bullet points:

- Involvement of customers early at the design phase could help to avoid big changes in later phases and to have a successful CE.
- It could be beneficial for Norwegian maritime equipment suppliers to finish early phases like product design, drawing and technical details before customer specific engineering and purchasing to avoid changes and re-doing of work. Stages after design could still be performed concurrently.
- We suggest companies to ensure good communication and coordination with suppliers and customers, especially if offshoring or outsourcing.
- In order to reduce time and cost used on design and engineering work, customer requirements could be achieved through tailored customization with re-used design.
- Modularity through component sharing and cut-to-fit could be beneficial as it allows the customer to uniquely design the product around a base unit of components and enable unique dimensions to the product.
- Modular options could reduce lead-time and cost, while simultaneously maintain a great variety of products.

6.0 Conclusion

For the Norwegian maritime equipment suppliers, their competitive advantage is customization and their knowledge about the product. This enables the companies to produce based on costumer specific requirements and is order winning for the equipment suppliers, meaning that ETO is a competitive advantage. Due to this, a high level of standardization would decrease their competitive advantage on the market. However, this thesis found that they can take great advantage with using standard modules for some of the products. Modules allow the companies to benefit from economies of scale, decrease lead-time and decrease supplier power by purchasing higher volume while at the same time maintain a certain degree of customization. Modularization will probably not suit every company, neither every product. Nevertheless, modules should be organized so they fit most of the customers' needs. The market situation for ETO companies would affect their possibility for standardization and modularity. Supplier power could facilitate for more standardization and modularization. On the other hand, customer power will probably increase customization.

CE is extensively used by the equipment suppliers in this study. CE brings advantages like shorter lead-time and reduced cost. On the other hand, it may contribute to longer lead-time and higher costs if big changes occur late in the project. The companies should therefore be facilitating so that changes to the project takes place in the earlier phases, such as in the customer specific engineering phase. In later phases, few or none changes should be allowed. Changes with limited impact on the product structure could be allowed if it does not affect the project lead-time. However, if the customer requirements change within the project lead-time, changes should be considered. Our opinion is that with good inspection, specifications and project meetings in early phases between customer and supplier, number of changes in late phases could be avoided.

This case study has shown that outsourcing and offshoring of production are common in the industry. The advantages are extensive and important in order to reduce the total cost of the project. However, it should be taken into consideration that having production in another country also impose some challenges. Therefore, it will be important that the Norwegian maritime equipment suppliers ensure good communication with suppliers abroad, and that they have a good quality control of the production.

6.1 Limitations

To reinforce the findings proposed in this thesis, it would be advantageous to conduct several data collections from other sources than interviews and survey to get a deeper insight in the interaction between customer and supplier. If we have had gathered data from e-mails and other communication tools between customer and supplier, we could be able to see what kind of problems that occur in the communication. Further, we could see how often changes are communicated and how it is communicated.

Furthermore, if the number of respondents were increased, the generalizability of this study would be stronger. However, our data collection was weakened due to the situation with Covid-19 which occurred in March and consequently shut down most of the activity in Norway. We immediately experienced that number of respondents halted with the restrictions. People were requested to have home office, the situation for many companies got unpredictable, and this possibly led to companies not prioritizing to use resources to take part in our survey.

6.2 Further research

This thesis has researched the Norwegian maritime equipment suppliers supply chains and their view on standardization and modularization. It would be beneficial to conduct a research on the customer´s perspective when it comes to standardization and modularization of maritime equipment. Would customers choose suppliers with a lower degree of customization if this option were available? What are the customers thoughts on modularization of products, and would they see this as an advantage and a different option for customization to lower price and lead-time for the end product?

Our research was weakened due to the situation with Covid-19 and number of respondents stagnated. Therefore, it would be beneficial to conduct this research with a larger number of respondents. It could also be interesting to do the same research in other countries to see if they have the same problems regarding CE, project changes, communication and coordination.

These questions would be an interesting starting point to build on the findings from this thesis.

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Appendix 1 – Interview Guide

Project:

- Can you describe the project phases in some of your projects?
    - Do they differ from project to project?
- What are the stages to contract signing?
- After a contract is signed, can the customer always make changes to the project, or do you have any restrictions?
- Can you give us some examples of problems/challenges that occur during a project?
- Are there any standard processes in your organization?
- Can you estimate how many of your processes within the organization can be considered as varying and uncertain for each project?
    - What can be the causes for these variations and uncertainty?

ETO:

- Is your company using only an ETO approach? If not, what are your other business models?
    - If multiple approaches: What is the difference between ETO and the other business models you use?
- What advantages and disadvantages do you see by having an ETO business model?
- What other business model could be more fit for your company?

Products:

- How does your company develop customer specific products? Could it be adaptations of existing products or a total redesign?
- Can you estimate how many of the components in your products are entirely customized?
- Can you estimate how many of the components in your products are partially customized?
- Can you estimate how many of the components in your products are more or less standard?

Communication:

- How does your company communicate between all parts involved in the project? Also, with customers, suppliers and internal between departments?
- Do problems with communication occur, if so, why?

    - How is this affecting the project?

Customers:

- How are the customers involved in the project?
- Which factors does your company believe is the most important for your customers when choosing your product?
- What challenges does your company face when communicating with your customers?

Suppliers:

- Where are your suppliers located?
- Does your company outsource activities to other companies or offshore activities to other departments within the company?
- Which challenges do you meet by having a global network?
- What challenges does your company face when communicating with own suppliers?

Production:

- How many phases of your projects are performed by your company?
- What challenges does your company have with regards to production of customer specific products?
- Do your customers have the option to choose from modules?
- How would standardization and modularization of products and components affect your company?
    - How would this affect your ability to compete in the market?

Concurrency:

- Are any project phases performed concurrently/ simultaneously? If yes, how is it affecting the project?
    - Do you experience any advantages?
    - Do you experience any disadvantages?

Appendix 2 – Survey

Engineer to order

0 %

Denne undersøkelsen er en del av en masteroppgave ved Høgskolen i Molde. Alle svar er anonyme og kan ikke spores tilbake til respondent. Formålet med denne undersøkelsen er å finne ut mer om produksjonsmetoden engineer-to-order og dens konkurransefortrinn.

Vi setter stor pris på at du tar deg tid til å svare på denne undersøkelsen.

Jeg er klar over at resultatene fra denne spørreundersøkelsen blir brukt i en masteroppgave ved Høgskolen i Molde og samtykker til dette *

- ○ Ja, jeg samtykker
- ○ Nei, jeg samtykker ikke

Hvilke kunder leverer dere produktene deres til?

- ☐ Verft
- ☐ Ferdigbygde båter og fartøy
- ☐ Oljenæringen
- ☐ Fiskenæringen
- ☐ Annet

Dersom annet, gjerne utdyp

Hvilken påstand passer for din bedrift?

- [ ] Vi designer og engineerer produktet til kundens ønsker
- [ ] Vi har produktdesign klart før kunde er involvert, men produserer produktet etter ordre fra kunde
- [ ] Vi har design og komponenter klare, men setter sammen produktet etter kunde-ordre
- [ ] Vi produserer til lager og selger produktene til kunden derfra

Dersom dere designer og engineerer produktet til kunden, hvilke fordeler ser dere ved en sånn produksjonsstrategi?

- [ ] Kunden får det de ønsker
- [ ] Lavere risiko
- [ ] Kunnskapssterke
- [ ] Fleksibilitet
- [ ] Annet

Dersom annet, gjerne utdyp

Dersom dere designer og engineerer produktet til kunden, hvilke ulemper ser dere ved en sånn produksjonsstrategi?

- [ ] Lang ledetid
- [ ] Høye kostnader
- [ ] Komplisert produkt
- [ ] Usikkerhet
- [ ] Annet

Dersom annet, gjerne utdyp

I hvor stor grad opplever dere problemer i gjennomførelsen av prosjekt?

- ○ 1. Det forekommer ingen problemer
- ○ 2. Vi opplever problemer i liten grad
- ○ 3. Vi opplever jevnlig problemer
- ○ 4. Vi opplever problemer ofte
- ○ 5. Vi opplever problemer hver gang

Problemer som kan oppstå i deres prosjekt

- ☐ Mangel på materialer
- ☐ Utfordringer med endringer
- ☐ Kommunikasjon
- ☐ Lengre ledetid enn forventet
- ☐ Annet

Dersom annet, gjerne utdyp

Hvilke prosesser gjennomfører dere internt i bedriften?

- ☐ Design
- ☐ Engineering
- ☐ Innkjøp
- ☐ Produksjon
- ☐ Ferdigstillelse
- ☐ Levering

Hvilke prosjektfaser er gjennomført samtidig? (Kryss av for de som dere gjennomfører samtidig/parallelt)

- [ ] Design
- [ ] Engineering
- [ ] Innkjøp
- [ ] Produksjon
- [ ] Ferdigstillelse
- [ ] Levering
- [ ] Ingen

I hvilken grad opplever dere fordeler ved at faser blir gjennomført samtidig?

- ○ 1. At faser er gjennomført samtidig medfører ingen fordeler
- ○ 2. At faser er gjennomført samtidig medfører få fordeler
- ○ 3. At faser er gjennomført samtidig medfører noen fordeler
- ○ 4. At faser er gjennomført samtidig medfører flere fordeler
- ○ 5. At faser er gjennomført samtidig medfører mange fordeler

I hvilken grad opplever dere ulemper med at faser blir gjennomført samtidig?

- ○ 1. At faser er gjennomført samtidig medfører ingen ulemper
- ○ 2. At faser er gjennomført samtidig medfører få ulemper
- ○ 3. At faser er gjennomført samtidig medfører noen ulemper
- ○ 4. At faser er gjennomført samtidig medfører flere ulemper
- ○ 5. At faser er gjennomført samtidig medfører mange ulemper

I hvilken grad er produktene bedriften din leverer standardisert?

- ◯ 1. Vi leverer ingen standardprodukter, kun kundespesifikke produkter
- ◯ 2. Vi leverer få standardprodukter, men for det meste kundespesifikke produkter
- ◯ 3. Vi leverer en like stor andel standard og kundespesifikke produkter
- ◯ 4. Vi leverer flere standardprodukter enn kundespesifikke produkter
- ◯ 5. Vi leverer kun standardprodukter, ingen kundespesifikke produkter

Moduler betyr at et produkt er delt opp i ulike komponenter som kan bli separert og kombinert i nye varianter, noe som betyr at man
kan produsere ulike produkter med de samme modulene. Et eksempel på dette er valgmuligheter ved bestilling av ny bil, hvor man kan velge mellom ulike kombinasjoner når det gjelder farger, materialer og ekstrautstyr.

Har kundene deres muligheten til å velge mellom moduler når de bestiller et produkt?

- ◯ Ja
- ◯ Nei
- ◯ Vet ikke

Hvis nei, i hvilken grad er det aktuelt for dere og eventuelt tilby kundene deres å velge mellom moduler?

- ◯ Vårt produkt kan ikke deles opp i moduler
- ◯ Våre kunder ønsker ikke dette alternativet
- ◯ Vi har ikke gjort en vurdering om dette
- ◯ Det kunne vært aktuelt å tilby
- ◯ Vi utarbeider/ønsker å tilby dette
- ◯ Annet

Dersom annet, gjerne utdyp

Hvordan kommuniserer dere med deres kunder?

- [ ] Mail
- [ ] Gjennom system
- [ ] Muntlig/Telefon
- [ ] Prosjektmøter
- [ ] Annet

I hvilken grad opplever dere utfordringer med kommunikasjon med kunder?

- ○ 1. Vi opplever aldri problemer med kommunikasjon
- ○ 2. Vi opplever svært sjeldent problemer med kommunikasjon
- ○ 3. Vi opplever sjeldent problemer med kommunikasjon
- ○ 4. Vi opplever ofte problemer med kommunikasjon
- ○ 5. Vi opplever svært ofte problemer med kommunikasjon

Hva skyldes eventuelt disse utfordringene?

Hvordan kommuniserer dere med deres leverandører?

- [ ] Mail
- [ ] Gjennom system
- [ ] Muntlig/Telefon
- [ ] Prosjektmøter
- [ ] Annet

I hvilken grad opplever dere utfordringer med kommunikasjon med leverandører?

- ○ 1. Vi opplever aldri problemer med kommunikasjon
- ○ 2. Vi opplever svært sjeldent problemer med kommunikasjon
- ○ 3. Vi opplever sjeldent problemer med kommunikasjon
- ○ 4. Vi opplever ofte problemer med kommunikasjon
- ○ 5. Vi opplever svært ofte problemer med kommunikasjon

Hva skyldes eventuelt disse utfordringene?

Hvilke faktorer mener du er avgjørende for at kundene velger deres produkt?

- [ ] Kvalitet
- [ ] Pris
- [ ] Service
- [ ] Plassering og lokasjon
- [ ] Kunnskap
- [ ] Annet

Hvor sent i prosessen kan kunden gjøre endringer og dere gjennomfører de? Sett kryss ved det passende svaret for de ulike prosjektfasene

	Kunden kan ikke gjennomføre endringer	Kunden kan gjennomføre svært få endringer	Kunden kan gjennomføre få endringer	Kunden kan gjennomføre flere endringer	Kunden kan gjennomføre mange endringer	Kunden kan gjennomføre alle ønskelige endringer
Design	☐	☐	☐	☐	☐	☐
Engineering	☐	☐	☐	☐	☐	☐
Innkjøp	☐	☐	☐	☐	☐	☐
Produksjon	☐	☐	☐	☐	☐	☐
Ferdigstillelse	☐	☐	☐	☐	☐	☐
Levering	☐	☐	☐	☐	☐	☐

Setter dere bort noe av produksjonen til andre firma?

- ○ Ja
- ○ Nei
- ○ Vet ikke

Hvis ja, i hvilken grad opplever dere dette samarbeidet som vellykket?

- ○ 1. Samarbeidet fungerer dårlig
- ○ 2. Dette samarbeidet har noen utfordringer
- ○ 3. Dette samarbeidet fungerer greit
- ○ 4. Dette samarbeidet fungerer bra
- ○ 5. Samarbeidet fungerer svært bra

Har dere filialer i andre land hvor dere produserer?

- ○ Ja
- ○ Nei
- ○ Vet ikke

Hvis ja, i hvilken grad opplever dere dette samarbeidet som vellykket?

- ○ 1. Samarbeidet fungerer dårlig
- ○ 2. Dette samarbeidet har noen utfordringer
- ○ 3. Dette samarbeidet fungerer greit
- ○ 4. Dette samarbeidet fungerer bra
- ○ 5. Samarbeidet fungerer svært bra

Produserer dere lokalt i egen bedrift?

- ○ Ja
- ○ Nei
- ○ Vet ikke

Hvis ja, hvilke fordeler opplever dere ved dette?

Appendix 3 – Survey answers

Which customers do you deliver your products to?

Shipyards	21
Already built boats and vessels	17
Oil industry	15
Fish industry	8
Other	5

What claim is right for your business?

We design and engineer the product to the customer´s need/requirements	22
We have product design ready before the customer is involved, however, we produce after customer order	17
We have design and components ready and assemble the product after customer order	13
We produce products to stock and sell products from there	3

If you design and engineer the product for the customer, what benefits do you see from such a production strategy?

Fulfill customer request	25
Lower risk	4
Knowledge	13
Flexibility	21
Other	3

If you design and engineer the product for the customer, what disadvantage do you see from such a production strategy?

High costs	17
Long lead-time	16
Complicated product	9
Uncertainty	6
Other	1

To what extent do you experience problems in project execution?

1. No problems appear	0
2. We experience problems to a small extent	16
3. We regularly experience problems	9
4. We often experience problems	2
5. We experience problems every time	0

Problems that may arise in projects

Lack of materials	7
Challenges with changes	21
Communication	13
Longer lead-time than expected	14
Other	1

What processes do you carry out internally in your company?

Design	26
Engineering	25
Purchasing	25
Production	20
Assembly	21
Delivery	22

What project phases have been completed concurrently?

Design - Engineering	8
Design – Engineering - Purchasing	4
Design – Engineering – Purchasing - Production	4
Engineering - Purchasing	4
Engineering – Purchasing - Production	3
Purchasing – Production - Assembly	1
Design - Purchasing	1
None	2

To what extent do you experience the benefits of having phases completed concurrently?

1. Phases completed concurrently brings no benefits	1
2. Phases completed concurrently brings few benefits	2
3. Phases completed concurrently brings some benefits	13
4. Phases completed concurrently brings several benefits	10
5. Phases completed concurrently brings many benefits	0

The degree to which you experience the disadvantages of phases being completed concurrently

1. That phases are completed concurrent does not bring disadvantages	2
2. That phases are completed concurrent bring few disadvantages	12
3. That phases are completed concurrent bring some disadvantages	9
4. That phases are completed concurrent bring several disadvantages	3
5. That phases are completed concurrent bring many disadvantages	0

To what extent are the products your business supplies standardized?

1. We do not supply any standard products, only customer-specific products	4
2. We supply few standard products, but mostly customer-specific products	7
3. We deliver an equal share of standard and customer-specific products	6
4. We supply more standard products than customer-specific products	10
5. We only supply standard products, no customer-specific products	0

Does your customers have the option to choose between modules when ordering a product?

Yes	19
No	7
I do not know	1

If no, to what extent is it relevant and possible to offer your customers to choose between modules?

Our product cannot be divided into modules	2
Our customers do not want this option	2
We have not evaluated it	0
It could have been relevant to offer	0
We prepare/want to offer this	4
Other	2

How do you communicate with your customers?

Mail	27
Systems	3
Telephone	26
Project meetings	24
Other	2

To what extent do you experience challenges with communication with customers?

1. We never experience communication problems	1
2. We more rarely experience communication problems	9
3. We rarely experience communication problems	15
4. We often experience communication problems	2
5. We very often experience communication problems	0

How do you communicate with your suppliers?

Mail	27
Systems	4
Telephone	27
Project meetings	14
Other	3

To what extent do you experience challenges with communication with suppliers?

1. We never experience communication problems	1
2. We more rarely experience communication problems	9
3. We rarely experience communication problems	17
4. We often experience communication problems	0
5. We very often experience communication problems	0

What factors do you think are crucial for customers choosing your product?

Quality	15
Price	12
Service	19
Location	4
Knowledge	24
Other	4

How late in the process can the customer make changes and you implement them?

	The customer cannot make any changes	**The customer can make very few changes**	**The customer can make few changes**	**The customer can make several changes**	**The customer can make many changes**	**The customer can make any desired changes**
Design		1	3	9	7	7
Engineering			6	9	6	5
Purchasing	2	2	15	5	2	1
Production	4	7	10	4	2	
Assembly	5	14	2	3	2	1
Delivery	9	11	3	1	1	2

Do you outsource production to other suppliers?

Yes	23
No	4
I do not know	0

If so, to what extent do you find this cooperation successful?

1. This cooperation works poorly	0
2. This cooperation has some challenges	2
3. This cooperation works ok	2
4. This cooperation works well	13
5. This cooperation works very well	6

Do you have branches in other countries were you have production?

Yes	15
No	12
I do not know	0

If so, to what extent do you find this cooperation successful?

1. This cooperation works poorly	0
2. This cooperation has some challenges	0
3. This cooperation works ok	6
4. This cooperation works well	6
5. This cooperation works very well	3