Master's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
Department of Mechanical and Industrial Engineering

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Relationships Between Build Location and PSV Shipbuilding Times

Master's thesis in Global Manufacturing Management
Supervisor: Marco Semini
June 2023

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Preface

This master's thesis marks the culmination of a two-year journey towards a Master's degree in Global Manufacturing Management. With a specialization in Production at the Department for Mechanical and Industrial Engineering, it marks my final semester as a student at Norwegian University of Science and Technology (NTNU). These 30 credits were made possible by the support of many individuals to whom I owe a depth of gratitude.

I would like to express my appreciation to my supervisor, Associate Professor Marco Semini, for his guidance and professional discussions throughout this semester. I am also grateful to Per Olaf Brett from Ulstein International AS for sharing his professional insights.

Lastly, I extend my heartfelt gratitude to my friends, my girlfriend, and my family, for providing invaluable motivation throughout my academic journey.

Trondheim, June 2023

JO Aas Gullbrekken

Abstract

The shipbuilding industry of specialized ships constantly looks for ways to improve competitiveness in terms of cost-efficiency and reduced production and delivery times. Still, more research is needed to study the effect of several location-specific factors affecting shipbuilding times between countries. This study aims to investigate whether factors related to the build location of a ship can influence production and delivery times in specialized shipbuilding. The author examines publicly available data on the shipbuilding times of Platform Supply Vessels (PSV) and investigates the existing literature on the subject. The results provide evidence that the build location of a ship can explain a lot of the variance in production and delivery time between different regions and countries. To further investigate what aspects within the build location that can affect PSV shipbuilding times, data is collected on PSVs and their shipyards' proximity to cluster, offshoring of hull production, offshoring of design, and vertical integration of design capabilities. Multiple Linear Regression is used to analyze the obtained data, consisting of 1322 PSVs produced at shipyards located in 6 different countries. This study assess why proximity to cluster, hull offshoring, or design offshoring do not have any significant effect on production and delivery times of specialized ships. The research also offers evidence and explanation as to why vertical integration of design capabilities can reduce the production and delivery time of PSVs. This study contributes to the literature on factors affecting the time performance in specialized shipbuilding, as well as highlighting how the build location of a ship can affect its production and delivery time.

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Abbreviations

CAD	Computer Assisted Detection
CD	Customized Design
CGT	Compensated Gross Tonn
CODP	Customer Order Decoupling Point
DT	Delivery Time
DV	Dependent Variable
ETO	Engineer-To-Order
GLM	General Linear Model
GT	Gross Tonnage
ICT	Information and Technology Systems
IHS Maritime	Information Handling Services Maritime
IT	Information technology
ISM	International Safety Management
MRA	Multiple Regression Analysis
OECD	Organization for Economic Co-operation and Development
OSV	Offshore Supply Vessel
PSV	Platform Supply Vessel
PT	Production Time
R&D	Research and Development
SCM	Supply Chain Management
SEA Europe	European Shipyards and Maritime Equipment Associations
SOV	Service Operation Vessel
SPMS	Shipbuilding Performance Management System
VI	Vertical Integration
VIF	Variance Inflation Factor

1 Introduction

This chapter introduce the purpose and drive of the thesis. It outlines the goals of the research, provides the research questions, and describes the scope of the study. Lastly, an outline of the thesis is presented.

1.1 Background and motivation

Shipbuilding is a worldwide industry that has stood the test of time. It is a strategic and competitive industry, which has survived several fluctuations in the global economy during its history (Hossain and Zakaria, 2017). The demand for new ships is reliant on the global economy. Although demand has been unstable in periods of time, there has been a stable increase of trade over the history, increasing the need for seaborne trade through ships (Bruce and Garrard, 2013). However, the shipbuilding industry's dependence on the global economy means it is also affected by external factors. These can range from environmental issues, war times, or any other global events that may reduce or increase the demand for new ships. For instance, the Norwegian shipbuilding industry, which traditionally have been highly dependent on the offshore oil and gas industry, faced difficulties when oil prices fell in 2014 and 2015 (Jakobsen et al., 2019). Such external factors can create challenges, but also situations that open for new markets and actors.

The global shipbuilding market has moved from long-established shipyards in Europe, to shipyards located in Asia, in countries like South-Korea, India and China. Traditionally, European yards built several ship types in conventional and high-volume cargo-carrying segments, such as tank ships, bulk carriers and container ships (Semini et al., 2023). However, there are still some niche markets where the European industry has a technological edge, which have made them able to compete effectively (Bruce and Garrard, 2013). The European shipbuilding industry has focused on innovation and building complex, high-value ships (Gasparotti, 2018, Alfnes et al., 2021). As demand for ships related to the offshore oil and gas industry decreased with the mentioned oil price drop, the demand for other specialized vessels such as ferries, fishing, aquaculture, and cruise vessels increased. However, these segments have much smaller order volumes. Concurrently, rising materials and labor costs, and the growing market share of specialized ships in Asia, have made European shipbuilders look for ways to make their shipbuilding industries more competitive. (Sea Europe, 2019)

Some countries' shipbuilding industries have been investigated and compared. These are often comparisons between a few specific countries. Examples of these types of comparisons are papers like Strandhagen et al. (2020) and Eich-Born and Hassink (2005). These compare Norway to South Korea, and Germany to South Korea. Other authors and organizations such as the Organization for Economic Co-operation and Development (OECD), produce "peer reviews" and papers describing the shipbuilding industries of one single country. However, a gap in the literature remains in comprehensive comparisons across multiple countries and environments, considering both general and specific shipbuilding characteristics.

Several authors have identified general factors affecting the global shipbuilding industry. Bruce and Garrard (2013) identifies labor costs, performance, exchange rates, political support and industry structure as general reasons for the fluctuating market shares in the shipbuilding industry. Pires Jr et al. (2009) highlights capacity, technology, industrial environment, productivity, building time and quality as performance indicators and influencing factors in shipbuilding. Semini et al. (2018), Semini et al. (2022) and Semini et al. (2023) have deep dived into production strategies and factors likely to affect ship production and delivery time in the Norwegian and European shipbuilding sector. Semini et al. (2018) first looked at different production strategies effect on performance for Norwegian shipbuilders. Then, Semini et al. (2022) based on quantitative data revealed how different factors affected time-performance when producing OSVs (Offshore Support Vessels) at Norwegian yards. The factors the authors of said paper considered were offshoring strategy, ship size, ship complexity, repeat production and market situation. Semini et al. (2023) focused on the European industry, where the focus were factors within the build strategy of the 76 ships considered in the study. As Semini et al. (2023) points out, these papers have provided much needed performance benchmarking for shipbuilders, and some knowledge on how shipyard production affect shipbuilding time for shipowners. However, there is a need to investigate how other factors influence shipbuilding times, both internal and external to build strategy. As Asian competitors can utilize their low labor and/or material costs, Semini et al. (2023) emphasize how it is of critical importance for European shipyards to investigate what factors that can improve their shipbuilding performance to qualify and win jobs in the future.

Another reason as to why it could be interesting to investigate the specialized shipbuilding market is the likely increase of demand for work boats for both Norwegian and global shipbuilders. Norges Rederiforbund (2023) explain how the demand for offshore support vessels will increase in the coming years as Norwegian shipowners expect to build 215 new ships in the next 5 years. Jørgensen (2023) described how 79% of the shipowners are considering Norwegian shipyards for the contracting of these new ships. Simultaneously the high energy demand and increased focus on renewables in the energy sector has led to a significant increase in interest and exploration of the offshore wind market (IEA, 2019, Díaz and Soares, 2020). This development can give an increase in the demand for specialized vessels such as Service Operation Vessels (SOVs) in the coming years, which are built to support offshore wind farms. Offshore Support Vessels (OSVs) are provided by European shipbuilders and some of the biggest shipbuilding nations of the world, such as China, South Korea, and USA (OECD, 2017). As these countries and others represent a significant threat to the European industry, it will be of the upmost importance for European shipyards to focus on competitiveness in the coming years.

The specialization project aimed to investigate and map the shipbuilding market for PSVs, with a focus on identifying the shipbuilding countries' production characteristics and differences between them. However, this research could not conclusively determine which factors that are more crucial for time-performance. A qualitative literature study and investigation unveiled several potential elements such as government regulations, design capabilities, industrial clusters, and offshoring, all of which appeared to hold substantial importance from a regional perspective, warranting further investigation. These factors were found by examining what similarities and differences that existed in the different countries production characteristics, compared to their average production and delivery times. Shorter production and delivery time were detected in countries associated specifically with vertical integration of design capabilities and equipment suppliers, cluster exploitations, and offshoring of hull work. The study was empirical, with little use of quality-proof methods such as statistical analysis methods. Additionally, the research relied mainly on qualitative findings, suggesting that future research should focus on quantitative studies to provide more precise information on how these factors affect shipbuilding production and determine the importance of each factor.

1.2 Problem description

Production characteristics in the shipbuilding industry vary across the world. Each shipbuilding nation has its own unique industrial environment, and within these regions, shipyards show distinct production features. Depending on their build locations, shipyards leverage their strengths and adapt to challenges to carve out their competitive advantages (Pires Jr et al., 2009, Semini et al., 2016). For example, a known characteristic of the Chinese shipbuilding industry is its low labor costs. This has traditionally enabled shipyards in China to use more man-hours per produced ship as a competitive advantage (Tsai, 2011). Norwegian shipbuilding is known for its availability of skilled labor, being able to produce highly specialized vessels (Semini et al., 2018).

To effectively compare different shipbuilding industries, it could be beneficial to focus on a single ship type of comparable complexity, such as Platform Supply Vessels (PSVs). These specialized ships, supporting the offshore oil and gas industry, have been globally produced since the 1950s, representing various production strategies across different countries. Bruce and Garrard (2013) explain how a technologically advanced and high-performance industry can offer a competitive advantage, but that technology in shipbuilding is easily transferable and in constant change. This encourages the need for development and improvement in the shipbuilding supply chain of specialized ships to improve the industry's competitive advantage continuously.

There is a difference between the ship types that are produced, both within and between countries. Some papers have analyzed ship portfolios of countries alongside examinations of production characteristics, such as Semini et al. (2018) and Semini et al. (2022). These papers explore how the Norwegian shipbuilding industry produces specialized ships. The Norwegian industry must exploit their highly productive and skilled workforce, as the labor costs are very high (OECD, 2017). Semini et al. (2022) state the need to identify factors likely to affect ship production time and the use of statistical measurements to compare the performance of several yards.

Praharsi et al. (2022) describe how the literature discussing general shipbuilding industry performance is meagre. However, some parameters have been used to measure performance in the global shipbuilding industry. Pires Jr et al. (2009) evaluate shipbuilding performance from a competitiveness perspective based on production costs, building time, and quality. Bruce and Garrard (2013) explain how Compensated Gross Ton (CGT) per man-hour is another measurement tool for performance in shipbuilding. Semini et al. (2022) discuss how production- and delivery time could be the sole performance measurement tool in the shipbuilding industry. Semini et al. (2022) propose production and delivery time as the primary performance measurement tool in the shipbuilding industry. While they explore factors influencing Delivery Time (DT) and Production Time (PT) in the Norwegian shipbuilding industry, more studies are required to examine production characteristics across various shipbuilding nations and identify the most impactful factors on specialized ship production. This study will focus on the performance indicator of time, as detailed in chapter 2.3.

The challenge of comparing shipbuilding industries on time performance arises due to the diversity in production characteristics across different countries. Each shipbuilding nation, influenced by its unique industrial environment, adopts distinct strategies to optimize productivity. Factors such as labor costs, skill levels, and the types of ships produced further complicate these comparisons. Utilizing statistical methods to analyze these factors allows for an objective and quantifiable comparison, offering a deeper understanding of the intricate interplay between various influencing factors. Consequently, it enables us to distinguish patterns, trends, and potentially causal relationships that might otherwise go unnoticed. Thus, utilizing statistical techniques and addressing these gaps in the literature could aid decision-makers in forming competitive strategies for companies competing in specialized shipbuilding markets in the future.

1.3 Research questions and approach

Production and delivery time in shipbuilding is not only a performance measure for a shipyard but also a key competitive factor in order to compete in a demanding industry. Thus, it is of importance to know what factors affect the production and delivery time and which strategies that can potentially reduce it. Through the specialization project, some factors that could affect production and delivery time were introduced. However, the need for investigating these and possibly other factors found in the literature is still of importance. This way, a more holistic picture of the industry and competitive factors can be established. The present study aims to investigate relevant factors when exploring production and delivery time in the specialized shipbuilding industry. Improving the knowledge of the global shipbuilding industry of PSVs, by identifying essential factors for shipbuilders to focus on in their production environments, could possibly influence an improvement of the competitiveness in the industry. Furthermore, a quantitative analysis is needed in order to properly investigate how each factor affect the production and delivery time of a ship. The following Research Questions (RQs) are presented:

The work with the specialization project discovered how certain aspects of the build location of a ship appeared to affect the time performance of shipyards. However, this was just qualitative, empirical findings. To investigate whether this could be true, the first research question is formulated:

RQ1: Do production and delivery times of PSVs depend on the build location of the ship and, if so, what could be the reasons?

Further investigating the literature on specialized shipbuilding and production and delivery times revealed certain aspects related to the build location that seemed likely to explain some of the variance in production and delivery times between PSVs. To test whether these areas could influence PSV shipbuilding times, the following research question were made:

RQ2: Are production and delivery times of PSVs tied to the following factors regarding the build location: proximity to cluster, offshoring of hull production and offshoring of design?

When studying offshoring and other factors related to the build location of a ship, the literature revealed how the location, and especially the level of integration of the design department, could affect production and delivery times of specialized ships. It appeared a natural extension of the study to investigate this as well, and the third research question was formulated:

RQ3: Is production and delivery times of PSVs tied to the degree of vertical integration of design capabilities at the shipyard?

The investigation of the research questions is divided in two parts. One part is the qualitative investigation of literature, and the other part is the quantitative, statistical analysis of collected data. The quantitative analysis of collected data related to RQ1 aim to verify the differences in PSV shipbuilding times between build locations. The qualitative investigation tied to RQ1 seeks to identify the characteristics of specialized shipbuilding industries that might explain variations in production and delivery times of PSVs related to its build location. This is fundamental to understand the complexities and nuances of diverse shipbuilding environments. RQ2 and RQ3 are designed to both qualitatively and quantitatively analyze how these identified factors impact delivery and production times for PSVs. Both assessing the factors trough qualitative and quantitative analysis is critical for understanding the magnitude of each factor's effect. By using a quantitative approach, the need for an objective, measurable method of comparison that is highlighted in literature is met. Answering these research questions can contribute to the knowledge base and literature on time performance in specialized shipbuilding.

1.4 Research scope

While investigating these research questions, the shipbuilding industry will be in focus. Shipbuilding is an Engineer-To-Order (ETO) manufacturing industry (Semini et al., 2022). Whereas several ETO-industries contain many similarities, this study will only look at the distinctive characteristics of ETO that appear in the shipbuilding industry. Similar industries, such as the construction industry, can therefore be of some relevance but will be outside the scope of this thesis.

This thesis will concentrate on the segment of specialized ships represented by the ship type Platform Supply Vessels (PSVs). PSVs are similar in complexity and size, and are specialized vessels built all over the world. The ship type is chosen to ensure a homogeneous dataset that is suited for statistical analysis. Although these ships are built all over the world, the scope of this thesis will be the countries with the most significant production of PSVs, to meet the assumptions of Multiple Regression Analysis. This is further explained in chapter 3. Some countries that produce PSVs will thus not be included in the study. The shipbuilding industry will be described in more detail in chapter 2.1.

The study will include certain aspects within the field of production management, such as the supply chain of building a specialized ship. The main focus will be on the factors the literature highlights as necessary for shipbuilding performance, as well as some of the factors discovered in the specialization project. The findings of the specialization project are described in section 3.1.1 and will be referred to as both the specialization project and the preliminary study interchangeably throughout the thesis. When specifically used, it is referred to by its reference, Gullbrekken (2022).

The production performance will not be measured by the traditional cost parameter but by delivery and production time. This is further elaborated on in chapter 2.3. Production time, delivery time, shipbuilding times and time-performance will in this thesis be used interchangeably. However, it always refers to production and delivery time as it is the operationalized measurement method described in chapter 3. By "factors" affecting shipbuilding time-performance it is in this study meant descriptive aspects of the shipbuilding industry and production. The factors affecting shipbuilding time-performance are described in chapter 2.4.

Multiple Regression Analysis is in this study a quantitative, statistical method applied for investigating the relationship between the discovered factors and production and delivery time. Further elaboration and explanation on Multiple Regression Analysis is presented in chapter 2.5 and chapter 3.3.

1.5 Thesis outline

The thesis is divided into six chapters. The present table aims to provide an overview of the structure and outline of the project thesis.

Chapter	Content
1- Introduction	Provides the background information and motivation for the project. The overall research objective of the project is described, along with the research questions in focus throughout the thesis. Furthermore, the scope of the research is presented, and the thesis structure is listed.
2- Theoretical framework	Important theory in this chapter is given to support the rest of the thesis, with relevant information about the topics in question. The topics of shipbuilding, time performance, factors affecting production and delivery time in shipbuilding, and multiple regression analysis are covered.
3- Research methodology	The research methods that make out the project's research methodology are presented. Here, the research strategy of the project is explained. Methods such as literature study and data analysis are justified and explained in accordance to the research questions.

4-	Analysis and Results	This chapter describes the analysis and provides the results of the quantitative data analysis.
5-	Discussion	In this chapter, results from the research methods provided in the previous chapter are discussed. They are discussed in comparison to the research questions and previous research.
6-	Conclusion	The research questions of the thesis are directly addressed. The limitations of the research are highlighted, and suggestions for further work and future research are proposed.

2 Theoretical background

This chapter aims to provide insights into the theoretical aspects considered in the research project. It will provide important information about the topics discussed throughout the thesis. Background information on the topic of shipbuilding is provided. As shipbuilding is a broad subject, this chapter contains what topics within the field of shipbuilding that are of focus in this thesis. The information width and dept of each topic is limited to what is needed to understand and discuss them further. Thus, for some topics there will be more specific and thorough information than for others. The shipbuilding market segment of specialized ships is also described. Within this topic, in particular performance in shipbuilding is examined. Thereafter, the factors affecting the performance factor of time in the shipbuilding industry is examined. This topic was briefly addressed in the specialization project of Gullbrekken (2022), as mentioned in chapter 3.1.1. However, the topic is reviewed a lot more broadly, thoroughly and with several additional aspects in this thesis. Finally, the topic of Multiple Regression Analysis (MRA) is examined to determine a mutual understanding of related terminology before the analysis and results are described in chapter 4.

2.1 Shipbuilding

Shipbuilding is a complex production process, involving numerous processes from the planning and design phase to delivering a ship (Semini et al., 2014). The shipbuilding industry is competitive, always leading the edge of technology (Bruce and Garrard, 2013). In Norway, the shipbuilders have had the ability to construct and improve technologically advanced vessels since the Viking age (Holte and Moen, 2010). Norwegian shipbuilders have traditionally built various types of ships. Since the 1990s, Norwegian yards have focused on complex, technologically advanced and specialized ships to cope with the rising competition of particularly Asian countries (Semini et al., 2023). These ships are mainly, but not limited to, cruise vessels, fishing vessels and offshore support- and supply vessels, designed and used to assist the offshore oil and gas industry.

Ships are big, technologically complex steel constructions, sometimes with a varying degree of customer-specific customizations. Some ships can be built as standard products produced in long runs over many years, while other ships are often built in low quantities with specific requirements from the customer. (Berry and Hill, 1992, Semini et al., 2014) Even ships that are built in series can have variations between the individual vessels, which can alter the shipbuilding processes between them (Andritsos and Perez-Prat, 2000, Mello and Strandhagen, 2011). The world fleet of ships can be classified by two main categories, cargo carrying vessels and work vessels. These categories, presented in table 2.2, are developed by IHS Markit and Fairplay – a Lloyd's register. This classification system will be used throughout the thesis and is also used in the IHS Seaweb database, as presented further in chapter 3.3. It should be noted that this classification excludes certain ship types not directly relevant to this study, such as warships. For the full classification, see Appendix A.

Level 1	Level 2	Level 3
Cargo Vessels	Tankers	Liquified Gas
		Chemical
		Oil
		Others
	Bulk Carriers	Bulk Dry
		Bulk Dry/Oil
		Self-Discharging Bulk Dry
		Other Bulk Dry
	Dry/Cargo/Passengers	General Cargo
		Passenger/General Cargo Ship
		Container
		Refrigerated Cargo Ship
		Ro-Ro Cargo
		Passenger/Ro-Ro Cargo
		Passenger
		Other Dry Cargo
Work Vessels	Fishing	Fish Catching
		Other Fishing
	Offshore	Offshore Supply
		Other Offshore
	Miscellaneous	Research
		Towing/Pushing
		Dredging
		Other Activities

Table 2.1 - Ship types

The different ship types presented in table 2.2 have their own product specifications, which shipbuilders strive to accommodate as effectively as possible. Some ships feature highly innovative solutions, which vary between shipyards and countries, while others have similar solutions and production characteristics. Certain ship types, such as Tankers and

Bulk Carriers, are typically built in high volumes, with East-Asian shipyards holding the majority of the market share. Other ship types are more specialized and customer-specific, such as Offshore Supply Vessels (OSVs) and some Passengers vessels, where Europe has a strong market position. (Semini et al., 2023)

The focus of this thesis is Work Vessels, in particular PSVs. PSVs are Offshore Supply Vessels, with specifications designed to operate in offshore platform environments (Aas et al., 2009). They are primarily used to transport people, materials, and goods from shore to offshore platforms (Díaz-de-Baldasano et al., 2014). PSVs play a crucial role in the marine industry due to their ability to perform cruising-, logistics-, and dynamic positioning operations in support of offshore platforms and connected vessels (Satpathi et al., 2017). As they are specialized for efficient supply, they are suited for support operations worldwide (Ulstein, 2022). A significant feature that Ulstein (2022) points to, is that the PSVs are fit to readapt into other segments if the market would change in the future. The typical Platform Supply Vessel is versatile, with great cargo- and material storage capacity and looks somewhat like figure 2.1, which shows a conceptual design of a PSV from Ulstein Shipyard.

Figure 2.1 – Platform Supply Vessel (Ulstein, 2022)

2.1.1 Shipbuilding manufacturing strategy

Skinner (1969) defines manufacturing strategy as a coordinated plan that aligns a company's manufacturing policies, resources, and capabilities with the overall business strategy to achieve competitive advantage. He believes that manufacturing strategy should focus on the following key dimensions:

(1) Capacity and scale: Decisions related to the size and capacity of manufacturing facilities, which directly impact the ability to meet demand.
(2) Location and facilities: The choice of location and the design of manufacturing facilities, which impact logistics, supply chain, and access to resources.
(3) Technology and equipment: Investments in technology and equipment that enable the company to improve efficiency, quality, and innovation.
(4) Workforce and skills: The development of human resources, including training, skill development, and management practices, to improve the company's manufacturing capabilities.
(5) Vertical integration: Decisions regarding the extent to which the company controls the various stages of the production process, from raw materials to finished products.

Skinner (1969) emphasizes the need to make trade-offs and choices across these dimensions to create a coherent and aligned manufacturing plan that supports the company's overall competitive strategy. Olhager et al. (2001) argue that there are seven decision categories within manufacturing strategy, but they fit within the five key dimensions of Skinner (1969). These key dimensions will be further addressed in chapter 2.3 and chapter 2.4.

Leong et al. (1990) divides manufacturing strategy in to two main parts: (1) important decisions for the long-term position of the manufacturing operations, and (2) competitive priorities that are based on the business goals. Lamb (2003) explains how strategy at a shipyard is about aligning three main parts; (1) business plan, (2) shipbuilding policy and (3) build strategy. The business plan is the overall company plan for the foreseeable future, usually around five years time. It decides what products that the company will make and sets goals for profits and costs. The shipbuilding policy is the overall strategy for production, answering questions regarding production facilities use and development, offshoring, equipment, research and more. The build strategy is when an order comes in, and the company must decide how the specific project should be built to best fit the shipbuilding policy and business plan. Semini et al. (2023) refers to build strategy in shipbuilding as the process that specifies what is to be produced, how, when, and where it should be produced and with what resources.

Shipbuilding will in this study be assessed keeping all these authors definitions and interpretations of shipbuilding manufacturing strategy in mind. Following the argumentation of Semini et al. (2018), the dimensions of Skinner (1969) all have an effect on performance. For instance, as Beckman and Rosenfield (2008) discuss, shipbuilders emphasizing cost-efficiency will have a markedly different manufacturing strategy compared to a firm prioritizing flexibility or capacity. As the concepts of manufacturing strategy in shipbuilding involves several production-specific aspects, it is important to know and understand how the typical shipbuilding supply chain is organized.

2.1.2 Shipbuilding supply chain

The project of building a ship includes various processes, which creates a complex supply chain. Strandhagen et al. (2022) describe the supply chain in a typical shipbuilding process as seen in figure 2.2, with five main phases.

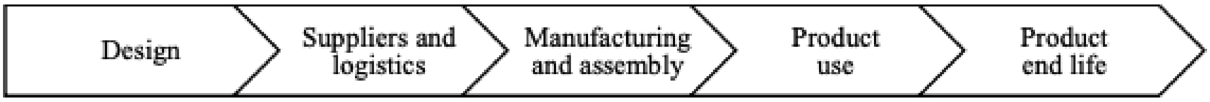

Figure 2.2 - The shipbuilding supply chain (Strandhagen et al., 2022)

Design

Lamb (2003) define design as the activity involved in producing drawings, specifications and other data needed to construct an object. The author argue that the design phase is the foundation for the production, use and operation, and end of life of a ship. Thus, decisions taken in this phase affect the whole shipbuilding supply chain. Moyst and Das (2005) claim that the design phase is critical in determining lead time and cost, as the design phase sets the foundation for the entire construction process. Semini et al. (2014) describes with figure 2.3 how the design phase involves a series of steps and processes, often divided into preliminary design, contract design, and detailed design.

The design process in shipbuilding is however not a one-time activity but rather an ongoing and repeated process that coexists with the engineering and construction phases. Throughout the shipbuilding process, the design may undergo modifications and adjustments due to evolving technical requirements, regulatory changes, or construction-related challenges. Lamb (2003) discuss how close collaboration and communication between the design team, engineering team, and shipyard are essential to ensure a smooth transition from design to construction and successful project completion. Haartveit et al. (2012) investigate different integration alternatives for ship designers and shipyards and discuss how shipbuilding-relevant business factors are affected by the choice of integration level. The authors developed a typology of three integration alternatives, namely Ownership, Partner Yard, and Market Yard. *Ownership* implies that the designer and the shipyard are part of the same company, leading to the highest level of collaboration and vertical integration. In this study, this is what we call *integrated* design. *Partner Yard* implies long-term contractual agreements or strategic alliances between the ship designer and the shipyard, facilitating improvement in collaboration over time. *Market yard* represents a scenario with no long-term relationship. Here, the focus is on one project at a time, leading to less collaboration between the designer and the yard. If a ship is constructed with a degree of either partner yard- or market yard strategy, it is in this study considered as *outsourced* design. Haartveit et al. (2012) analyze how these alternatives affect strategic, market, product and technology, and economic factors. For instance, the authors point out that ownership ensures full control over capacity and integral technologies, facilitates knowledge sharing and cost control, but comes with high investment requirements. On the other hand, the Market Yard approach requires no investment but might lead to high transaction costs due to contract negotiations and complex coordination.

Garcia Agis et al. (2020) find three insights into how ship design practitioners can improve the effectiveness of design processes. These are (1) put more effort into the contextual factors affecting the ship design process, (2) improve the communication with vessel owners and other stakeholders, and (3) improve the agility of the design process. When it comes to specialized ships, such as offshore supply vessels, research vessels, or ferries, the design phase is arguably a even more critical phase. These ships often have unique operational requirements, advanced technologies, and complex systems that require a high level of expertise and attention to detail during the design process (Agis et al., 2016). Moreover, specialized ships may also have to comply with additional regulatory requirements or classification rules, making the design phase more challenging and demanding. The design of specialized ships often involves a high degree of customization and collaboration with the end-users and equipment suppliers, ensuring that the final design meets the specific needs and expectations of all stakeholders (Erikstad and Levander, 2012, Ebrahimi et al., 2021b).

Suppliers and logistics

Shipbuilding is as mentioned a complex production process where shipyards can potentially use various suppliers and several concerns related to logistics exists. Whereas historically shipyards were responsible for the entire production of a ship, shipbuilding has lately become a global business where companies can focus on their core competence and outsource other activities (Mello and Strandhagen, 2011). An example of this is how China have previously imported key equipment and components from other countries (Tsai, 2011). Another example is how Norway is known for entirely or partly offshoring steel hull production to Eastern European countries such as Romania, Ukraine, Poland and Turkey (Semini et al., 2018, Strandhagen et al., 2022). Strandhagen (2022) identifies logistics as a possible key contributor to cost efficiency at shipyards in the future. The globalization of the shipbuilding industry makes coordination and cooperation between the shipyard, suppliers, and other actors important for continuous improvement in the shipbuilding supply chain (Mello and Strandhagen, 2011).

Manufacturing and assembly

This is the ship production process performed at a shipyard. Storch and Lim (1999) divide the production process in three processes, (1) hull (steel construction, body), (2) outfitting (machinery, electrical work, etc.), and (3) painting. Manufacturing work in the shipbuilding industry is highly characterized by manual, labor intensive work, especially the steel work (Semini et al., 2018). The production process, including manufacturing and assembly, will be further addressed in section 2.1.3.

Product use

In the product use phase, the ships are finished and in operation by their shipowners. Activities for the shipyard in this phase include repair work, after-sales operations, and maintenance services. Strandhagen et al. (2022) emphasize how this phase is of importance, as high-quality maintenance can reduce the ships operational downtime and prolong a ships lifetime, which are important for maintaining customer satisfaction for shipbuilding companies.

Product end life

The product end life phase consists of ship decommissioners remanufacturing, recycling, or reusing ships. This phase can be done by shipyards, retrofitting or converting ships (Strandhagen et al., 2022). Some ships are scrapped by companies solely focusing on the ship's end life.

All these phases and stakeholders are presented in table 2.3 and are important for the shipbuilding supply chain. However, some are more important for this study than others. The main phases in focus in this thesis will be the design-, suppliers and logistics-, and manufacturing and assembly phase. In other words, the process under investigation is from the very start of the procurement process, until the ship is delivered. To further investigate these areas of shipbuilding, a summary of typical shipbuilding project characteristics is presented in the next section.

Stakeholder	Description	Shipbuilding process involvement
Shipowner	Strandhagen et al. (2022) describes how the shipowner provides specifications and requirements and are involved from the get-go. This is illustrated by Semini et al. (2014) with the Customer Order Decoupling Point (CODP) in figure 2.3. Shipowners supervise tests, give feedback, and engage in concept discussions throughout the process to ensure a successful project outcome.	Design Manufacturing and assembly Product use Product end life
Shipyard	The shipyard is responsible for requesting and providing technical information from and to suppliers regarding equipment when needed. The shipyard also manufactures blocks, constructs the hull, and assembles equipment in accordance with the schedule. It negotiates contractual terms, purchase materials and equipment, and oversee delivery. Additionally, they conduct sea trials, make necessary adjustments, and offer support to suppliers throughout the process.	Design Suppliers and logistics Manufacturing and assembly Product use Product end life
Ship designer	The ship designer's tasks include defining requirements and developing general specifications while considering efficiency, safety, cost, and other aspects. It also creates technical specifications and detailed drawings according to the project schedule.	Design Suppliers and logistics Manufacturing and assembly
Equipment suppliers	In shipbuilding, equipment suppliers are responsible for providing technical information about the main equipment when required. They create quotations, supply technical specifications, and address inquiries. Suppliers deliver equipment according to specifications from engineering and the shipyard, and they also inspect and test equipment, generate reports, and offer technical support throughout the process.	Suppliers and logistics Manufacturing and assembly

Table 2.2 - Shipbuilding phases and main stakeholders, adapted from Mello et al. (2017) and Strandhagen et al. (2022)

2.1.3 Shipbuilding project characteristics

In shipbuilding the customer often is included in the design, engineering, and procurement-related decisions for a ship. This is what Semini et al. (2014) calls Customized Design (CD). As shipyards produces ships on a project basis, with specific customizations for each order, several authors define them as an ETO-companies (Hicks et al., 2000, Mello and Strandhagen, 2011;, Nam et al., 2018;). Shipyards can do all or a number of several manufacturing processes, such as designing, engineering, constructing and repairing ships to the costumer's orders (Nam et al., 2018). Table 2.4 provides an overview of common characteristics in ETO-production companies. Several of the characteristics of ETO-production can be identified in the shipbuilding industry of specialized ships.

Characteristics of Engineer-To-Order production
High degree of customization to meet the customers' demands
Low volume of engineered products, in one of a kind to small series
Deep and complex structures, with assembly processes
Varying volume requirements of different components
Combination of highly customizable and standardized products
Combination of advanced system control and not
Generally high costs, risks, and lead times

Table 2.3 - Characteristics of ETO-production (Gullbrekken, 2022), based on Mello and Strandhagen (2011) and Hicks et al. (2000)

Semini et al. (2014) illustrate the different activities that appears in a typical shipbuilding project, where the product has a customized design. This process is presented in figure 2.3. A project with customized design has the CODP at the very start of the project, where the customer often is included in almost every activity throughout the process. In this figure, all the phases of the shipbuilding supply chain are represented by one or more activity.

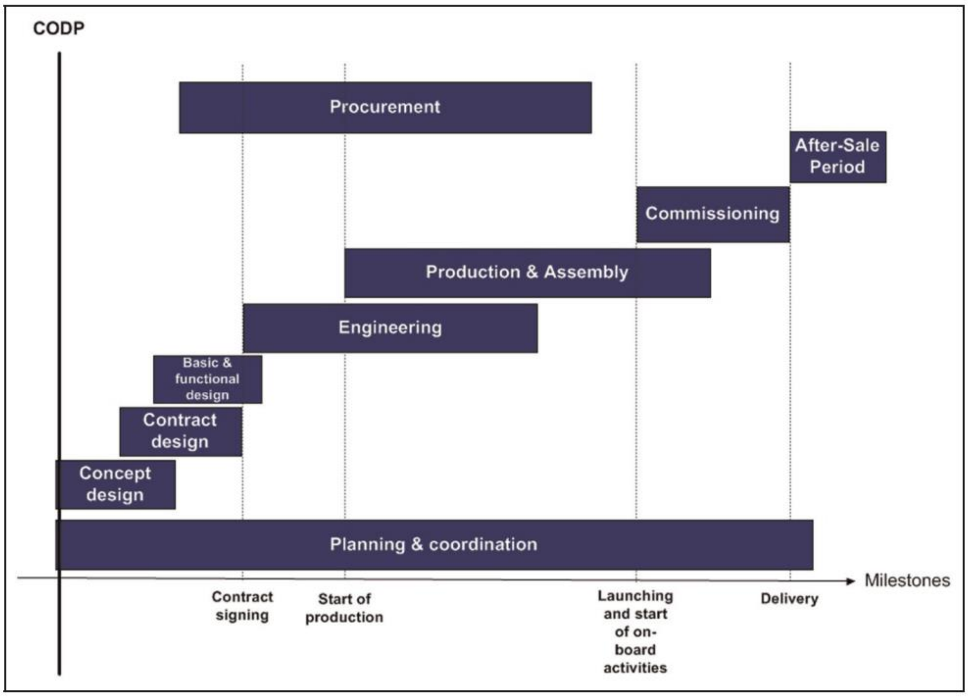

Figure 2.3 – Activities and CODP in shipbuilding with customized design by Semini et al. (2014)

Within these activities lies the production steps of a shipbuilding project. The production steps are the physical construction and outfitting steps in a shipbuilding project, from the start of production until delivery of the finished product. These steps have been illustrated by Semini et al. (2018) in figure 2.4. Some knowledge of these steps is important to understand the building process of a ship, and the steps are thus briefly presented below.

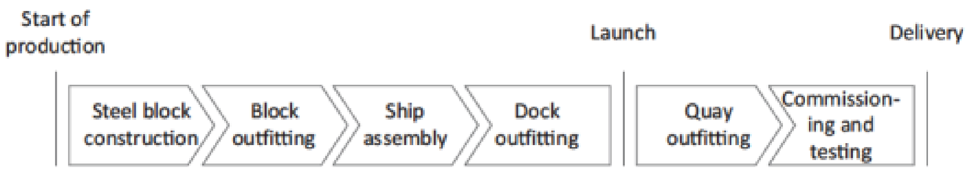

Figure 2.4 - Shipbuilding production process created by Semini et al. (2018)

Steel block construction

The construction of steel blocks involves producing parts for use in section assembly or steel prefabrication, assembling steel blocks, surface treatment and painting. Blocks are the steel parts the ship's hull are made and assembled from. (Hagen, 2023)

Block outfitting

Block outfitting is a critical process with the main objective of pre-outfitting surface treated sections or blocks without welding or cutting the structure. This involves outfitting blocks with pipes, equipment, and cabling. Key aspects to consider during block outfitting include organizing, coordinating, and planning for a multi-skilled workforce, ensuring efficient material logistics, local stores, and workshops, as well as cautiously outfitting near section/block interfaces to avoid complications. (Hagen, 2023)

Ship assembly

The step of ship assembly contains moving the mentioned blocks and assemble them into the ship's hull. This is usually done on dock or a slipway, where the sections are welded together, and pre-outfitted systems are installed. (Hagen, 2023)

Dock outfitting

Dock outfitting involves carrying out sufficient work to bring the ship afloat while performing the necessary outfitting suitable for dock or slipway conditions. Key aspects to consider during dock outfitting include executing exterior work or tasks requiring dock/slipway facilities, keeping transport paths clear for people and equipment, ensuring proper infrastructure for utilities such as gas, air, and electricity within the ship, and minimizing extensive transport of materials and personnel in and out of the ship. (Hagen, 2023)

Quay outfitting

Outfitting of the ship is completed and system functions are tested before the ship is set to perform sea-trials. (Hagen, 2023)

Commissioning and testing

Commissioning and testing are important to ensure that the newly built vessel operates safely and according to the design specifications, regulatory requirements and the shipowners wishes. This ship trials are performed, and the ship is handed over to the shipowner, marking the end of the shipbuilding process and the beginning of its operational life. (Hagen, 2023)

2.2 Shipbuilding market

To understand the shipbuilding market is essential when assessing shipbuilding and aspects of the shipbuilding industry. This section aims to provide a brief overview of the shipbuilding market, by providing a table consisting of the drivers and enablers of shipbuilding from a shipyard's point of view. This is created to gain an understanding of what the shipbuilding market consists of and what aspects one could be wise to keep in mind. It is however not a framework that describes all the complex connections and interactions of the global shipbuilding market, as that could be a thesis of its own. The chapter is based on the reasoning and reflections of Brett (2023), and is supplemented with the rationales of Lamb (2003), Mello and Strandhagen (2011), and Hossain and Zakaria (2017).

Shipbuilding is a highly cyclic industry, where both smaller market segments and the overall market for ships fluctuates due to various reasons (ECORYS, 2009). Porter (1985) explain that the market conditions push innovation. This can be described as drivers, which represent the initial drive for business and innovation, and enablers, which are external factors that support and allow this business to happen. Drivers and enablers of shipbuilding can vary significantly across different market segments, with some being more crucial than others depending on the specific industry focus. For instance, in the Norwegian and Northern European shipbuilding industry, competitiveness on other aspects than costs have become increasingly important. Due to significantly higher costs compared to competitors in Asia, the question arises as to how shipbuilders in these regions can remain competitive in the future (Semini et al., 2018).

Drivers and enablers of shipbuilding from a shipyard's point of view		
	Internal aspects	External aspects
Drivers	Culture Value creation Technological development Economic growth and profitability Increase competitiveness	Demand Sustainability Suppliers
Enablers	Competence, experience and expertise of shipyard Available capacity Sustainability Digitilazation	Financing Political decisions Political support Global economy

Table 2.4 – Some drivers and enablers of the shipbuilding industry

Drivers and enablers for shipbuilding are presented in table 2.4, based on the work of Brett (2023). Lamb (2003) also discuss similar drivers. Both drivers and enablers are divided in “Internal” and “External” aspects. Internal aspects are the internal motivation and skillsets of the shipyard, meaning the capabilities that facilitates for a new shipbuilding project for the shipyard. External aspects are market considerations or other external aspects that facilitates for a new shipbuilding project. It should be noted that these definitions are not derived directly from an author or a literature work, and even though they are inspired by both literature and experts mentioned, they are the author of this study's definitions.

External drivers propel the industry forward and contain the demand for trade and building new ships. External drivers also contain the drive for sustainability, which in turn creates demand for new, sustainable solutions and new, sustainable ships. Mello and Strandhagen (2011) also claims that suppliers can act as an indirect, external driver for shipbuilding, as they drive the demand for value creation. As the external drivers primarily drive the demand for new ships, the internal drivers of a shipyard are focused on factors such as the culture for pursuit of value creation and work, the accumulation of competence and experience, and the focus on achieving economic growth and profitability. Shipyards always aim to increase their competitiveness, which perhaps is the most essential internal driver.

Enablers, on the other hand, facilitate and support the industry's growth by fostering a competitive environment and ensuring the effective execution of projects. Key enablers include access to financing and guarantee arrangements from shipowners and others, political decisions that facilitates shipbuilding, the demand for new ships and the growing demand for sustainability both within and outside the sector. Hossain and Zakaria (2017) explain how external enablers for shipbuilding also contain political decisions and political support, which provides the basis for building new ships. They argue that strong governmental support and political stability is needed to facilitate the capital-intensive industry that is shipbuilding.

2.3 Performance in shipbuilding

Performance in ETO-manufacturing industries can be measured by several different aspects of the production of a company. It could, for example, be measured based on what the order winners of the industry are. Some consider economic profits as the main measurement of whether a company performs well or not. Others consider product quality, costs, productivity, or delivery time as performance indicators for a company. (Semini et al., 2014) In the global shipbuilding industry, performance can be measured by different parameters. Several authors have investigated this topic, and some key findings will now be presented.

Lamb and Hellesoy (2002) point out that the size and complexity of ships in shipbuilding pose challenges for productivity measurement using conventional metrics. Therefore, they propose a three-factor framework for measuring shipbuilding performance. The first factor, "Technology," assess aspects such as automation level, standardization degree, and the availability of CAD tools. The second factor, "Management," includes planning and coordination, employee involvement, and the use of performance metrics as vital indicators. The third factor, "Workforce," considers elements such as the level of training and education, experience, and the availability of skilled labor.

To integrate these factors, Lamb and Hellesoy (2002) introduce the Shipbuilding Performance Measurement System (SPMS), which offers a set of performance indicators to monitor progress and identify areas for improvement in shipbuilding projects. SPMS assess shipbuilding productivity using a measure called "complexity-adjusted labor hours per compensated gross ton (CGT)." Bruce and Garrard (2013) explains how Compensated Gross Tonnage (CGT) per man-hour can be used as a measurement tool for performance in shipbuilding. CGT is one of the most frequent measurement methods in the shipbuilding sector that factors in the labor and material resources needed to construct a ship, considering its size and complexity (Pires Jr et al., 2009). By adjusting labor hours with CGT, the Bruce and Garrard (2013) aim to make productivity comparisons more meaningful and relevant.

Pires Jr et al. (2009) assess performance in shipbuilding using several criteria from a competitiveness perspective, including production costs, building time, quality, capacity, technology, industrial environment, and productivity. Their approach aims to help shipyards identify best practices, areas for improvement, and better understand their competitive position in the market. Production costs vary significantly among shipyards in different countries, as labor costs can diverge considerably, for example, between Western Europe and Asia. Pires Jr et al. (2009) measures man-hours per output unit, where the output unit is measured in CGT, to measure the production performance of shipyards. By measuring performance on costs this way, the productivity of a shipyard in a country becomes dependent of the country's labor costs. In competitive parts of the shipbuilding industry, as for large, relatively simple vessels, there is great competition and cost is often of key importance. However, for niche markets such as for technologically specialized ships, Bruce and Garrard (2013) argues that higher levels of costs can be sustained. As costs is not necessarily the main order winner for specialized ships, other aspects of the production can be considered.

In their study, Pires Jr et al. (2009) also evaluate quality as a performance indicator. They describe quality not as a direct reflection of the product itself but as a concept encompassing four components that focus on market requirements. These components include (1) maintenance-related costs, useful life, and secondhand value of the ship, (2) the shipyard's ability to meet the shipowner's specifications (flexibility), (3) after-sales availability and efficiency, and (4) supervision during the construction period (reliability and cost-reduction). Pires Jr et al. (2009) further investigates how capacity can lead to increased productivity and shorter building times. At the same time, Pires Jr et al. (2009)

states how technology and managerial capabilities is important factors when assessing a shipyards competitiveness and efficiency, along with labor productivity.

A shipbuilder's performance is affected by some factors that are specific for one country or region. This is what Pires Jr et al. (2009) defines as industrial environment. These factors are external to the shipyard's own attributes such as the facilities, the capacity, and the technological level of the shipyard. The factors considered by Pires Jr et al. (2009) within industrial environment lies within the categories of (1) product chain organization, (2) workforce and (3) shipbuilding policies. A more detailed discussion on the topic of industrial environment will be provided in chapter 2.4.

Colin and Pinto (2009) aim to analyze and compare the performance of shipyards using a benchmarking method, primarily focusing on asset turnover as an essential performance metric. The authors evaluate shipyard capacity using production capacity and asset turnover as parameters. They quantified shipyard production capacity based on the number of ships that a shipyard can manufacture within a specific timeframe, typically expressed in CGT per year. The researchers evaluated asset turnover as the ratio of a shipyard's yearly revenue to its total assets, which includes physical assets such as land, buildings, equipment, and inventory. Asset turnover is an efficiency measure that shows how effectively a shipyard utilizes its resources to generate revenue. Colin and Pinto (2009) use these measures to evaluate the performance of 20 shipyards from different countries, including Brazil, China, Germany, Italy, Japan, South Korea, and the United States. They analyze data from 2000 to 2006, considering factors such as production capacity, labor productivity, asset turnover, and financial ratios. Their findings suggest that there is a wide variation in performance among shipyards, with some demonstrating high levels of efficiency while others trailed. They identify several factors that contribute to these differences, including the size of the shipyard, production techniques, management practices, and the degree of vertical integration.

A key competitive factor in ETO markets is time performance (Hicks et al., 2000). Hicks et al. (2000) discuss how improving time performance consists of two components: reducing lead-time and increasing the reliability of lead-time estimates. The reliability of lead time estimates can be an order winner for shipyards as it meets the customers strict demands on delivery performance. As another example, Semini et al. (2023) substantiates how time can function as an order winner in good market times, and how short response times is generally associated with lower costs and high efficiency within the manufacturing sector. Semini et al. (2022) discuss how time could be a sole performance measurement tool in the shipbuilding industry. Both Semini et al. (2022) and Semini et al. (2023) investigate what factors that can influence and affect production and delivery time in the Norwegian and European shipbuilding industry. They consider different aspects of production and production strategies of Offshore Support Vessels (OSV) and investigate how it affects time-performance.

However, Semini et al. (2023) point out how short lead times are not always required by customers, such as in cases of fleet renewal. Semini et al. (2023) also argue that for shipbuilders, having some slack can be beneficial as it offers flexibility to execute tasks in the most suitable sequence and timing, allowing a more balanced use of key resources and lower peak manning levels per project. Longer lead times can also enable economies of scale by facilitating parallel ship construction and reduce the risk of delivery delays, which can be more harmful to a shipyard's reputation than slightly longer delivery times (Semini et al., 2023).

Factors	Summary of factor	Authors
Cost	Lower costs than the competitor is an order winner, especially for large, "simple" vessels. In niche markets for technologically specialized ships, higher costs can be sustained due to their unique features and capabilities.	Pires Jr et al. (2009) Bruce and Garrard (2013) Semini et al. (2023)
Time	Short response times and reliable lead time estimates can be an order winner for a shipyard. Longer lead times can provide flexibility, balance resource use, and reduce the risk of delivery delays. Time-performance can be measured by *Production Time* and *Delivery Time.*	Pires Jr et al. (2009) Hicks et al. (2000) Semini et al. (2022) Semini et al. (2023)
Industrial environment	Country or region-specific factors external to shipbuilders build strategies impact the shipyard's facilities, capacity, and technological level, ultimately affecting the efficiency and competitiveness of a shipyard.	Pires Jr et al. (2009) Bruce and Garrard (2013) Moyst and Das (2005)
Quality	Quality in shipbuilding performance is assessed through components like maintenance costs, useful life, shipyard's flexibility, after-sales support, and construction supervision. High-quality ships have	Pires Jr et al. (2009) Semini et al. (2018)

	better secondhand values, which can make a shipyard more competitive. The quality of a shipyard's work also directly affects its reputation, making quality a crucial aspect of shipbuilding performance.	
Technology	The level of technology used in shipbuilding, including automation, standardization, and CAD tools, plays a significant role in determining performance. Advanced technology can improve productivity, reduce errors, and optimize resource utilization, ultimately leading to better performance and competitiveness for shipyards.	Lamb and Hellesoy (2002) Pires Jr et al. (2009) Bruce and Garrard (2013)
Management	Effective management, which includes planning, coordination, employee involvement and more, can help optimize resource allocation, streamline processes, and ensure that projects are completed on time and within budget, contributing to better overall performance.	Lamb and Hellesoy (2002) Pires Jr et al. (2009) (Colin and Pinto, 2009)
Workforce	A skilled and experienced workforce with proper training and education is a key measurable indicator of shipbuilding performance. A competent workforce can improve productivity, ensure high-quality work, and enhance a shipyard's reputation, making it more competitive in the industry.	Lamb and Hellesoy (2002) Pires Jr et al. (2009) (ECORYS, 2009)

Table 2.5 - Some factors of affecting performance in specialized shipbuilding

2.4 Factors likely to affect time performance in shipbuilding

The authors of Semini et al. (2023) have over several years developed a table with 19 factors that are likely to affect ship production and delivery time. The table, visualized in table 2.6, distinguish between factors within- or external to the build strategy of a ship. The factors presented in the table is based on the European shipbuilding industry. However, as Semini et al. (2023) explain, it is based on research on factors affecting shipbuilding performance done by several authors including Pires Jr et al. (2009), Moyst and Das (2005), Lamb and Hellesoy (2002), and Semini et al. (2022). These papers discuss shipbuilding in several different regions of the world. These regions include, but are not limited to, Asia, Europe, and USA. The contents of the table can be linked to the previously investigated literature in chapter 2 and will now be further explored.

Factors	
Build Strategy	
F1	hull production offshoring
F2	offshoring of outfitting work
F3	level of integration with the hull yard (if applicable)
F4	offshoring of engineering work
F5	pre-erection outfitting
F6	overlap between engineering and production
F7	number and size of outfitting blocks to erection (lifting/transportation capacity)
F8	ship production stages performed under cover
F9	type of erection facility
F10	use of information technologies
F11	use of manufacturing technologies
F12	use of principles and practices from manufacturing theory
F13	vertical integration
Factors external to build strategy	
F14	market situation
F15	industrial environment
F16	product variety at the yard, degree of ship novelty and customization, and repeat production
F17	ship size
F18	ship complexity
F19	yard size/capacity

Table 2.6 - Factors likely to affect ship production and delivery time in European shipbuilding (Semini et al., 2023)

F1-F5 Offshoring

Strategies for offshoring has become an interesting aspect of some shipbuilding industries, such as the Norwegian and Dutch shipbuilding sectors (OECD, 2017, OECD, 2020). Offshoring is when a shipyard outsources some part of the production to a foreign location where the factor costs are lower (Semini et al., 2022). However, incentives for offshoring also include access to foreign countries' qualified professionals, particularly those with technical expertise (Stephan et al., 2008). Factors related to the industrial environment of a ship's build location can influence shipbuilder's decisions, as discussed later in this chapter. In Norway, wages are high, and it can be favorable to decrease the man-hours spent with such labor costs. Labor-intensive steelwork is therefore offshored to countries with lower labor costs, for example to countries in Eastern Europe. This also opens the opportunity to saving costs and building competitiveness, by focusing on improving the tasks a shipyard is left with. (Semini et al., 2022)

With specialized ships such as PSVs, offshoring for example the steel hull will give sufficient quality. At the same time, the "main" shipyard can focus on the customization, which is the competitive advantage. The amount of work done at a shipyard compared to what is offshored can differ between shipyards, which Semini et al. (2018) discuss in detail. Offshoring is as mentioned a common practice at some shipyards and can be considered both build strategy, and a strategic choice external to the build strategy. It can be the short- or long-term shipbuilding policy or manufacturing strategy of a shipbuilder to offshore some part of production, in relation to the theory presented in section 2.1.1.

The research of Semini et al. (2023) suggest offshoring lead to improved time performance, as fully integrated shipyards in Europe produce ships with longer production and delivery times, compared to Norwegian yards that practices offshoring of their hull production. As hull offshoring in literature is generally considered having an opposing effect to their findings, Semini et al. (2023) argue that other factors are likely to have a stronger effect on production and delivery time than hull offshoring (Semini et al., 2018, Semini et al., 2022). Amongst several factors, they highlight the industrial environment of a shipyard.

F6 Overlapping between engineering and production

Concurrently executing engineering and production activities is a common practice in shipbuilding and engineer-to-order industries to reduce delivery time. However, overlapping these processes may not always result in shorter delivery times, as it can complicate cost estimation, planning, and coordination, and potentially cause rework due to design mistakes and modifications (Semini et al., 2023).

Semini et al. (2023) investigated the effects of overlapping engineering and production on production and delivery times, and found that it primarily reflects varying engineering period lengths. Semini et al. (2023) suggests that extending engineering into the production phase primarily serves to enhance design adaptability by delaying engineering decisions. This approach simplifies the integration of cutting-edge technologies and accommodates last-minute customer requests, decisions, and alterations.

F7-F9 Facilities and Transportation capacity

Several aspects of how the facilities are at the shipyard can affect production and delivery time. Pires Jr et al. (2009) states how higher capacity for moving blocks as well as the erection facility used may increase productivity and reduce erection time. There can be a trade-off between capacity and technological or managerial capability, such as efficient production planning. Similarly, having the opportunity to perform certain production stages under cover can improve performance by reducing the impact of weather and other external factors. As we recall, Skinner (1969) describe how a manufacturing strategy of a shipyard amongst other things concerns how the manufacturing facilities and location is utilized. However, this aspect correlates with the shipyard's size and capacity strategy and will be further discussed under F19.

F10-F12 IT, manufacturing technology and theory

The use of information technologies can possibly improve communication, planning, and control in shipbuilding (Mello et al., 2015, Mello et al., 2017, Strandhagen et al., 2017). Strandhagen et al. (2022) argue that use of advanced manufacturing technologies within Industry 4.0, such as robotics and automation, can improve shipbuilding performance and reduce lead times. The authors argue that Industry 4.0 can facilitate collaboration between shipyards and suppliers and enable more efficient manufacturing logistics at shipyards. Performance and lead times can be further improved by applying principles and practices from manufacturing theory. As an example, Storch and Lim (1999) and Strandhagen et al. (2018) discuss how lean manufacturing could improve flow in shipbuilding and reduce lead time in ETO operations.

F13 Vertical Integration

Vertical Integration (VI) is in this study considered a strategic decision that a shipbuilder makes when deciding if it should include or exclude certain aspects of the supply chain in its organization or not. Such aspects of the supply chain could be the equipment vendor, design company, ship owner or others. Several authors assess and discuss Vertical Integration related to shipbuilding in their studies (Lamb and Hellesoy, 2002, Pires Jr et al., 2009). Lamb and Hellesoy (2002) investigated the impact of Vertical Integration on productivity, as described in chapter 2.3, on 26 shipyards in Europe, Asia, and USA. They found that companies with greater vertical integration were more productive. The study measured the degree of vertical integration as the value added by the shipyard compared to the total ship value. Haartveit et al. (2012) summarize the findings of Beckman and Rosenfield (2008) in Table 2.7.

Factors	Vertically Integrate to:	Vertically Disintegrate to:
Strategic Factors	- Develop and retain core and essential competences.	- Access a core or essential capability externally while working on its development internally.
Market Factors	- Control cost, quality, availability, features/innovativeness and environmental performance in unreliable markets. - Shift power relationships in the industry. - Reduce dependency on suppliers.	- Leverage competition among suppliers to access best-in-class performance. - Aggregate demand at suppliers thus generating economies of scale and improved responsiveness to variability in demand.
Product and Technology Factors	- Control integral or critical technologies. - Integrate design and production or service delivery under certain conditions	- Access current technologies not available internally. - Obtain leverage available from modular product architectures.
Economic Factors	- Minimize transportation and logistics costs. - Minimize transaction costs.	- Access lower production or service delivery cost. - Minimize investment costs.

Table 2.7 – Factors for and against Vertical Integration (Beckman and Rosenfield, 2008, Haartveit et al., 2012)

Porter (1998) describes how low degrees of vertical integration in a company can be compensated for by existing inside of a cluster. Clusters are interconnected companies within a specific field, located near each other and connected by commonalities and externalities (Porter, 2000). Being part of a cluster allows for communication and coordination between companies, driving improvements and benefits of scale while maintaining flexibility. In the shipbuilding industry, clusters can facilitate spill-over effects, such as technological advancements from other sectors. Maritime clusters can foster close collaboration with research and development (R&D), leading to innovative technologies and solutions. This way, clusters can be an effective alternative to vertical integration. (Porter, 1998)

Some shipyards have an integrated design department, as part of their Vertical Integration strategy. Other shipyards operate with external design companies either through close collaboration across geographical distances or by exploiting synergies in clusters. Moyst and Das (2005) argue that the design phase is critical in determining lead time and cost, as the design phase sets the foundation for the entire construction process. Errors or inefficiencies in the design can lead to delays and increased costs during construction. Lamb and Hellesoy (2002) suggest that design standardization, which refers to the extent to which a shipyard uses standardized designs on parts, can simplify production processes and improve productivity. This way, if ships are of different ship types with diverse designs, shipyards can still benefit from efficiencies when producing interim components.

The design phase is an opportunity to optimize the ship's layout, systems, and materials for cost and performance. Effective design choices can reduce the overall production and delivery time and reduce costs, making the shipyard more competitive (Moyst and Das, 2005). Integrating design and construction teams can also be of importance, to facilitate better communication, coordination, and decision-making. By fostering a collaborative environment, shipyards can identify potential issues early on, allowing for more efficient problem-solving and reducing the likelihood of costly delays or rework (Moyst and Das, 2005). This could be done both by what Haartveit et al. (2012) call ownership, in this study referred to as integrated design, or collaborating with a partner yard.

F14 Market situation

The state of the shipbuilding market can impact performance, particularly in terms of competition and demand. Semini et al. (2022) point out how the market situation is affecting the shipbuilding market trend in several ways. High market demand result in high shipbuilding activities, which again affect resource availability. Lack of materials, equipment and people can in turn create longer production and delivery times. As an example, Semini et al. (2022) further elaborates on how the level of demand for ships in the offshore oil and gas industry is closely tied to oil and gas prices, and is typically indicated by operating rates. In times of high demand, customers are keen to receive their ships as quickly as possible, and the industry is optimistic and driven. Conversely, during periods of low demand, shipowners may not be interested in receiving their ships, resulting in slow decision-making and approval processes that can impede progress. During such times, shipowners and yards often renegotiate and agree on delivery date postponements, relieving the shipowner from making the final payment and beginning to repay the loan. Consequently, one can assume that periods of low demand heighten the risk of delays caused by customers. Semini et al. (2022) found that the production times of OSVs decreases with increased product demand, while the production times increase as the intensity of global OSV production increase.

F15 Industrial Environment

An Industrial Environment consist of factors that are specific for one country or region, external to the shipyard's own attributes (Pires Jr et al., 2009). These factors are related to the location of the shipyard and can affect its time performance. Porter (2000) argue that location can affect competitive advantage as it influence productivity. Moyst and Das (2005) highlights several factors within industrial environment that can affect lead time and cost in ship design and construction. These factors include availability and cost of skilled labor, infrastructure, supply chain efficiency, and the competitive landscape in a country. Additionally, the authors emphasize that economic factors, such as exchange rates and inflation, can significantly influence shipbuilding costs. Furthermore, government policies, subsidies, and support for the shipbuilding industry can also impact the overall performance of shipyards. The authors underline the importance of considering these industrial environment factors when analyzing the factors affecting ship design and construction lead time.

Pires Jr et al. (2009) also investigate how the quality of a country's industrial environment affect performance. They discuss how supportive government policies, such as tax incentives and subsidies, can provide a favorable environment for shipyards to thrive, while strong infrastructure and skilled labor force can lead to increased productivity and cost-efficiency. On the other hand, unfavorable economic conditions or restrictive policies can hinder shipyard performance, leading to longer lead times and higher costs.

Bruce and Garrard (2013) emphasize how shipyards operating in countries with well-developed infrastructure, advanced technological capabilities, and a skilled workforce may have a competitive advantage and achieve better productivity and efficiency. Other aspects highlighted by Semini et al. (2016) is proximity to customers, competitors, suppliers and R&D. Closeness to customers provides companies with the opportunity to regularly communicate and create close relationships, with rapid delivery and realization of innovations. Proximity to competitors allows for shared learning, while it can simplify access to knowledge and technology. Closeness to suppliers provides the opportunity for close relationships with speedy technology development and mutual control and follow-up. Close relationships can also provide opportunities for quality improvements and joint design efforts. (Semini et al., 2016) Proximity to R&D can help ensure quality, and allow design and engineering to support manufacturing effectively (Beckman and Rosenfield, 2008). To have a distance between R&D-processes and production can negatively influence process and product innovation (Gray et al., 2013, Tate, 2014). In summary, proximity and close relationships with stakeholders can provide the grounds for efficient communication, quality, availability and innovation (Beckman and Rosenfield, 2008). This proximity can sometimes be exploited through clusters (Porter, 1998).

F16 Product variety, customization and repeat production

The variety of products produced at a shipyard can impact performance, particularly in terms of efficiency and coordination. Pires Jr et al. (2009) and Semini et al. (2022) point out how it can be beneficial to produce several equal ships. Some of the benefits they point out are worker experience and learning, design simplifications and the reuse of documentation. This is likely to have a beneficial effect on man-hour consumption, efficiency, and production time. The diversity of vessels produced at a shipyard can possibly influence efficiency and coordination, as Semini et al. (2022) similarly argued for the influence of market situation, potentially leading to improvements or challenges in production. Semini et al. (2022) analyzed the shipbuilding industry of OSVs in Europe and found that repeat production had no significant impact on production time, when it was not dependent on the offshoring strategy of the ship.

F17 Ship size

Ship size can impact production and delivery times, as it has a significant influence on the amount of work required per ship in terms of steel structure and outfitting (Semini et al., 2022). The size of ships being built can impact performance, for example in terms of increasing workload and logistics-related tasks (Pires Jr et al., 2009). Lamb and Hellesoy (2002), OECD (2007) and Pires Jr et al. (2009) argue and show how CGT can be used as a metric to consider both the ship's size and complexity. Semini et al. (2023) the effect of ship size measured in GT and its natural logarithmic transformation on production and delivery time of OSVs. Both Semini et al. (2022) and Semini et al. (2023) found that ship size does indeed have a significant effect on time performance in shipbuilding and argue that it must be considered when investigating shipbuilding production and delivery times.

F18 Ship complexity

Ebrahimi et al. (2021a) explores complexity in the maritime industry, specifically during building and designing a ship. The study identifies twenty-five different types of complexity grouped into nine factors. The author explain how complexity can explain some of the variance in ship design competitiveness. The complexity of ship can impact performance in terms of design and manufacturing. Ship complexity can increase if a ship includes more steel, pipes, and other materials that would typically have to be prepared, assembled, and installed per cubic meter. This could lead to more challenging installation work, due to space constraints, which could possibly increase production and delivery time. Semini et al. (2022) measure how the complexity of a ship, measured in CGT, affects shipbuilding and find that it is not significant and has little to no effect on production time for a sample of OSVs delivered from Norwegian shipyards.

F19 Yard size/capacity

Pires Jr et al. (2009) believes the capacity of a shipyard, which includes factors such as total area, erection area, and the ability to move blocks, can significantly impact productivity and building times. Pires Jr et al. (2009) argue that a shipyard with greater capacity to move blocks can likely achieve higher productivity and reduce erection time. The size and capacity of shipyards can impact performance in terms of logistics, production planning, and storage. As an example, the size of a shipyard's erection area can allow for construction of several hulls simultaneously (Semini et al., 2022). Parallel construction can expand a ships production time, but also provides the potential for substitution between capacity and technological or managerial capabilities. For instance, a shipyard that can assemble and stockpile several blocks at the same time can achieve similar building times as a shipyard with more advanced production planning and management capabilities. (Pires Jr et al., 2009, Semini et al., 2022) The OECD have explored different capacity measurement methods, including Total Factor Productivity (TFP), capital and labor-estimates, and maximum average production at a yard (Gal, 2013, Gourdon et al., 2023).

2.5 Multiple regression analysis

Multiple regression analysis is a multivariate analysis technique that can be used to analyze the relationship between a single dependent variable and several independent variables (Hair et al., 2014). The dependent variable represents the outcome we aim to predict, while the independent variables are the factors believed to influence the dependent variable. In essence, this approach helps us comprehend how multiple factors or predictors affect a single outcome. The multiple regression model is a widely known statistical dependence technique. It can be used to examine and predict the impact of several independent variables on a dependent variable, while considering the potential interaction effects between these variables. Hair et al. (2014) describe the Multiple Regression equation as:

$$Y = b_0 + b_1X_1 + \cdots + b_nX_n + e$$

Notation:

Y = dependent variable

X_i = independent variables

b_0 = Intercept value

b_i = regression coefficients

e = prediction error (residual)

2.5.1 Objectives of multiple regression

The essential starting point in multiple regression, as with all multivariate statistical techniques, is the research problem (Hair et al., 2014). Given its flexibility and adaptability, multiple regression is suitable for exploring nearly any dependence relationship. However, Hair et al. (2014) highlight that researchers must consider three primary concerns related to the research problem:

1. The appropriateness of the research problem
2. Specification of a statistical relationship
3. Selection of the dependent and independent variables

Research problems fit for multiple regression

Research problems fit for multiple regression is first and foremost classified within two classes, either *explanatory* or *predictable* (Hair et al., 2014). The research problem can either aim to explain the effect of independent variables on the dependent variable or investigate how the independent variables can predict the dependent variable.

Specification of a statistical relationship

The relationship between the dependent variable and the independent variables must have a statistical relationship (Hair et al., 2014). This involves developing a regression equation that represents the relationship between these variables. The equation includes estimated coefficients for each independent variable, reflecting the expected change in the dependent variable for a one-unit change in the independent variable, while holding all other independent variables constant.

Selection of the dependent and independent variables

According to Hair et al. (2014), it is important to consider (1) strong theory, (2) measurement error, and (3) specification error when selecting dependent and independent variables for multiple regression.

(1) Researchers must exercise judgment when selecting variables, based on theoretical reasoning, previous research, or expert knowledge, ensuring that they are relevant and appropriate for the research problem. Relying solely on empirical bases for variable selection may violate several basic assumptions of the model development can be violated (Hair et al., 2014).

(2) Measurement error refers to the need for variables to accurately and consistently represent the concept being studied (Hair et al., 2014). Measurement error occurs when the observed values deviate from their true values due to inaccuracies in data collection, measurement instruments, or data processing. Hair et al. (2014) recommend minimizing measurement error by using established, reliable, and valid measurement instruments, ensuring proper data collection procedures, and carefully processing the data. Reducing measurement error is critical as it influences the accuracy and reliability of the regression coefficients and overall results of the analysis.

(3) Specification error refers to incorrect model specification, such as omitting important variables or including irrelevant ones (Hair et al., 2014). Minimizing specification is important because it impacts the accuracy, validity, and reliability of the regression results. This can can be achieved by developing a strong theoretical foundation, thoroughly reviewing previous research, and consulting with experts in the field.

An important aspect to consider when assessing the objective and design of a multiple regression analysis is the sample size and statistical power. The power level represents the ability of the analysis to detect a significant effect when one truly exists. Higher power levels are desirable because they reduce the risk of Type II errors, which occur when a true effect is not detected due to inadequate sample size. A Type II error is described as the failure to reject a false null hypothesis. Hair et al. (2014) explain how a small sample size mean only strong relationships could be detected with any degree of certainty. Conversely, large sample sizes can cause almost any relationship to be statistically significant, as the model get overly sensitive. As the number of independent variables increases, the suggested, required sample size also increase. Hair et al. (2014) suggest a general rule of thumb for determining the minimum sample size. A sample size of at least 15 times the number of independent variables is needed to achieve generalizability of the results. However, this rule is not universally applicable and may vary depending on the specific research context and the degree of multicollinearity among independent variables.

2.5.2 Assumptions in Multiple Regression Analysis

Hair et al. (2014) explains how there are several assumptions about the relationships between the dependent and independent variables that affect the statistical procedure of multiple regression. The assumptions underlying multiple regression analysis apply both to the individual independent and dependent variables, and to the relationship between them. Violations of these assumptions may lead to errors in the model's results. To ensure the validity and accuracy of the results obtained from the regression model, and that the errors are the result of an actual absence of a relationship among the variables, it is important to understand and check for these assumptions. The assumptions of multiple regression are:

Linearity of the Phenomenon

The relationship between the dependent variable and each independent variable must be linear. The linear relationship between the variables represents how a change in the dependent variable is associated with a change in the independent variable. Hair et al. (2014) suggest testing for linearity, by investigating scatterplots and residual plots. If nonlinearity is detected, transformations of variables might be applied.

Multivariate normality

The variables in the multiple regression model should be multivariate normally distributed. Hair et al. (2014) describe how one of the most frequent assumption violations is the normality of one or both of the dependent and independent variable(s). Assessing whether the variables are normally distributed can be done by examining histograms, normal probability plots, or conducting statistical tests like the Kolmogorov-Smirnov test. If the assumption is violated, variable transformations or nonparametric methods might be considered. However, Williams et al. (2013) explain how as the sample size increase, the less importance this assumption has.

Constant variance of the error terms (Homoscedasticity)

The presence of unequal variances is one of the most common assumption violations (Hair et al., 2014). The error variance should be constant across all levels of the independent variables. Residual plots or Lavene's test for homogeneity of variance can be used to examine homoscedasticity. If heteroscedasticity is detected, variable transformations or weighted least squares regression can be used instead.

Independence of Error Terms

Each predicted value in regression is assumed to be independent and not related to any other predicted value. Hair et al. (2014) further explains how the error terms should be independent of each other, meaning that there should be no correlation between the errors of different observations. A Durbin-Watson test can be used to detect autocorrelation in the errors. Field (2013) explain how the range of the test statistic is from 0 to 4, with a value of 2 signifying the absence of correlation among the residuals. If the value exceeds 2, it suggests a negative correlation between adjacent residuals. Conversely, a value less than 2 suggests a positive correlation between the residuals.

Absence of multicollinearity

Multicollinearity describes when there is a strong correlation between two or more independent variables. Field (2013) explain how high levels of collinearity pose a threat to the models estimates and, as collinearity increases, three problems arise:

(1) Untrustworthy b-values
(2) Limiting the size of R (correlation-estimates)
(3) Difficulties in assessing the importance of variables

To detect multicollinearity, one can scan the correlation matrix for values above 0.80 when using IBM SPSS Statistics (Field, 2013). Hair et al. (2014) also suggest using the Variance Inflation Factor (VIF). When using VIF to analyze multicollinearity, one look for estimates of whether a variable has a strong relationship with the other variable(s). If the tolerance-value (1/VIF) is below 0.2, it indicates a problem (Menard, 2002). When the multiple regression analysis is done for explanatory purposes, testing for multicollinearity is very important, as it consists of assessing the regression coefficients (Williams et al., 2013). The ideal situation for a researcher is to have a high correlation between the independent variables and the dependent variable, but little correlation between themselves (Hair et al., 2014).

Hair et al. (2014) emphasize how testing for these assumptions is crucial, as violations can lead to biased or inefficient estimates and results. Corrective actions should be taken when necessary to ensure the accuracy and reliability of the multiple regression model.

2.5.3 Null hypothesis

Hair et al. (2014) state how the null hypothesis plays a central role in the testing of statistical analysis', such as Multiple Regression Analysis. The null hypothesis, often denoted as H0, is a fundamental concept in statistical inference. It represents a statement of no effect, no difference, or no relationship. In the context of multiple regression analysis, the null hypothesis typically posits that there is no relationship between the independent variables and the dependent variable in the population. That is, the coefficients associated with the independent variables in the population are zero. (Hair et al., 2014)

Specifically, in a multiple regression analysis with n predictors (dependent variables), the null hypothesis would be: $H0: \beta 1 = \beta 2 = ... = \beta n = 0$. This suggests that none of the predictor variables (X1, X2, ..., Xn) have any effect on the dependent variable (Y).

Statistical tests are then used to either reject or fail to reject the null hypothesis. If the null hypothesis is rejected, it means that there is sufficient evidence to suggest that at least one of the predictors has a significant relationship with the dependent variable. If we fail to reject the null hypothesis, it means that we do not have enough evidence to claim that the predictors significantly influence the dependent variable. However, it's important to remember that failing to reject the null hypothesis does not prove it true (Hair et al., 2014). It merely means that based on the data at hand, there's insufficient evidence to claim a significant effect. Similarly, rejecting the null hypothesis doesn't prove the alternative hypothesis; it just provides evidence supporting it.

In their book, Hair et al. (2014) emphasize the importance of correctly stating and interpreting the null hypothesis, as it forms the basis for statistical decision-making in multivariate analysis, including multiple regression. They also highlight the necessity of considering the practical significance of findings, not just statistical significance. This is because a variable could be statistically significant but have little practical impact, particularly in large samples where even small effects can be statistically significant.

3 Research methodology

This chapter presents the materials and methods of the research project. First, the research project’s procedure is outlined, and the specialization project (preliminary study) is given. Next, the literature study is presented and explained. Lastly, the data analysis and statistical methods used are described. The chapter provides a comprehensive explanation of the research methods that form the study's methodology, which are used to investigate the research questions introduced in chapter 1. For hypothesis testing, multiple regression analysis was used on a sample of PSVs delivered from various global shipyards.

3.1 Research procedure

A mixed-methods approach is chosen to structure the research procedure, as described by Creswell and Creswell (2017). This research aims to use methods within both qualitative and quantitative research methods to answer the research questions. Croom (2010) describes the difference between qualitative and quantitative research. Quantitative analysis is a process of observation and can be viewed as a validity of the research, as it has the ability of replication to verify results. Qualitative research methods try to interpret the findings of collected data, usually a form of text. This way, it differs from the quantitative methods, as it is highly affected by the views of the author, and the findings won’t necessarily let themselves be entirely replicated. Both qualitative and quantitative research methods have weaknesses, that to a certain extent can be compensated for by the strengths of another (Steckler et al., 1992).

This study draws upon preliminary findings from a specialization project performed in the autumn semester of 2022, while further enhancing and refining the scope of the study. The use of a mixed-methods approach allows for the triangulation of evidence, which improves the validity and reliability of the conclusions (Patton, 1999). The literature study component establishes a strong theoretical foundation, contextualizing the topic and identifying essential themes and perspectives. At the same time, the quantitative aspect of the research enables a thorough statistical analysis of the data, uncovering patterns, trends, and relationships that can inform the main research questions. Combining the insights from the detailed literature study and the careful statistical analysis, this research can achieve a comprehensive, well-rounded understanding of the phenomenon under investigation, contributing to both academic discussions and practical applications. The research procedure is visualized in Figure 3.1.

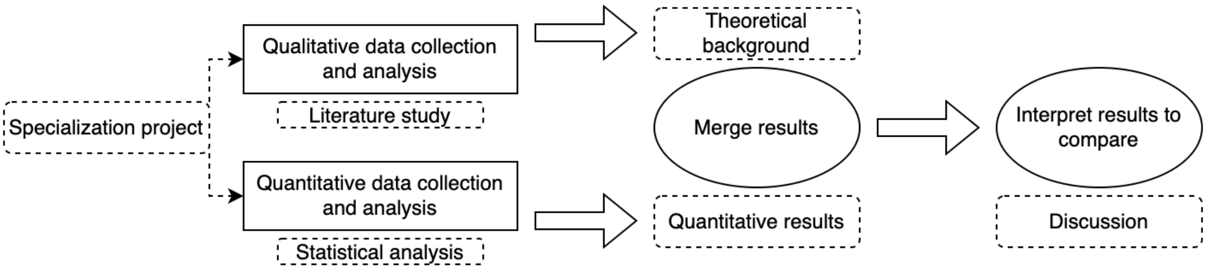

Figure 3.1 – Mixed-methods research approach inspired by Creswell and Creswell (2017)

3.1.1 Preliminary study

The research project is built on a preliminary study performed by the author of this thesis. The preliminary study was a specialization project of 15 credits, titled "Factors affecting shipbuilding, production- and delivery time in countries producing Platform Support Vessels" (Gullbrekken, 2022). In the preliminary study the results disclosed some factors that were likely to affect the production and delivery time of PSVs. It was further discussed what the characteristics of these factors were like in the different shipbuilding industries of the countries producing PSVs. These factors and their country-specific characteristics is presented in Appendix B. The table in said appendix was the result of the preliminary study.

In the preliminary study, a literature study was performed on the shipbuilding characteristics of the included countries. Only seven countries were investigated due to the time restrictions of the study. The specialization project also provided some insights in research methodology and shipbuilding literature, and some of the references used in this thesis were collected during work with the specialization project. The findings of the literature study in the preliminary study will to some extent be used in this study's Theoretical Background. However, a new literature study is performed to fit the scope and research questions of this study. The difference between what information was collected during the preliminary study and what is collected through the work of the master thesis is explained in the introduction of Chapter 2. The literature study aims to present several aspects of producing a specialized ship, and what external and internal factors that can affect this process.

3.2 Literature study

Ridley (2012) state how performing a literature study is essential to contextualize your work, investigate the literature gap and create the basis for the thesis. A literature study was thus conducted to ensure the understanding of the knowledge body of the research topic. It was further used to identify gaps in the existing knowledge body. It is also important to keep in mind that what we think we know could just be our subjective understanding. As Croom (2010) suggests, by asking ourselves if we really see what we think we see, we can challenge our perspectives and make sure that our views are not only of our creation. This concept was important while conducting the literature study, but also a constant reminder for the entire research process.

The literature study was inspired by the framework for a literature review process, developed by Brereton et al. (2007). The main inspirations from this framework were used to create a plan for the literature study, adapted from the preliminary study done by Gullbrekken (2022). The "Literature Study Plan" was separated in two main parts. Part 1, inspired by Brereton et al. (2007), and Part 2 called "Snowballing". Snowballing is the process of checking the references of the literature you have found to identify new, relevant literature (Wohlin, 2014). The author was introduced to snowballing by the study supervisor while working on the preliminary study. The supervisor stated that there often were papers of high quality in the literature listed in the papers that appeared in the initial literature search. These two parts resulted in the Literature Study Plan, inspired by Brereton et al. (2007) and adapted from Gullbrekken (2022), presented in Table 3.1.

	Literature study plan
Part 1	Define literature research question
	Define search terms
	Define inclusion and exclusion criteria
	Title & abstract screening
	Full text reading
	Literature inclusion & exclusion
Part 2	Snowballing
	Cited reference search
	Literature inclusion & exclusion

Table 3.1 - Literature Study Plan

Part 1 of the literature search began with defining the literature research questions, based on the research questions. The literature study performed in the preliminary project provided country-specific information about shipbuilding nations and some brief information about shipbuilding and factors affecting production and delivery times. However, a new literature study was needed to collect more thorough information on the global shipbuilding industry and extensive collection of information on the shipbuilding market, - manufacturing strategy, -supply chain, -production, and -performance, as well as Multiple Regression Analysis. Thus, the literature research question was made:

LRQ1: How is the shipbuilding project and market of specialized ships described, and what differences between build locations of specialized ships can be identified in the literature?

Subsequently the determination of search terms was performed in order to provide said information. The literature review process began by identifying and selecting relevant keywords. The search terms, presented in Table 3.2, were combined using "OR," and all search terms were free-text. During the initial search, concepts were combined using "AND". The primary search engines used was NTNU Oria, Scopus, Science Direct, OnePetro, Web of Science, Taylor & Francis, and Google Scholar. The most informative and high-quality search, conducted in Scopus, returned 294 results, which were subsequently exported to an Excel sheet.

Search Terms	Additional search terms
Shipbuilding Ship construction Shipyards Build Location Engineer-To-Order	Characteristics Market Manufacturing strategy Performance Competitiveness Supply Chain Production Time Delivery Time Multiple Regression Analysis

Table 3.2 - Search terms for literature search

The inclusion and exclusion criteria were then established. Following the title and abstract screening, several papers and other literature were deemed likely to contain highly relevant information. The literature was then assessed by full text reading and either excluded or included. Part 2 of the study, snowballing, uncovered additional relevant papers, articles, and peer reviews, culminating in a final literature list.

3.3 Data analysis

Multiple Regression Analysis is a widely used statistical method in data analysis that identifies and enables relationships between dependent variables and multiple independent variables. As Hair et al. (2014) note, regression analysis is a straightforward technique that allows researchers to examine and predict the impact of several independent variables on a dependent variable, while considering the potential interaction effects between these variables. In the context of the shipbuilding industry of specialized ships, production time and delivery time are critical factors that affect the competitiveness of shipyards. The present study aims to investigate the impact of Build Location, Vertical Integration of Design, Proximity to Clusters, Offshoring of Hull Production, Offshoring of Design, and control variables such as Ship Size, Supply Situation, Demand Situation, and Delivery Year on PSVs' production and delivery time. The variables are described in the subchapters 3.3.3 & 3.3.4, and presented in Table 3.3. Ultimately, the findings of this analysis can help inform decision-makers in the PSV shipbuilding industry and contribute to developing strategies for improving production and delivery times.

3.3.1 Objectives of the analysis

Multiple Regression Analysis (MRA) is a multivariate statistical method used to investigate the relationship between a single dependent variable and multiple independent variables. When applying Multiple Regression, Hair et al. (2014) points to three primary considerations that must be addressed: (1) appropriateness of the problem, (2) specification of a statistical problem, and (3) selection of dependent and independent variables.

(1) Multiple regression can be used to predict or explain a research problem. The objective of multiple regression in this thesis will be to explore and explain the effects of the independent variables on the dependent variable(s) given in the research model. The relationship between the independent variables listed in table 3.1 is aims to explain the variety in production time and delivery time of PSVs.
(2) The relationship between the dependent variable(s) and the independent variables has a statistical association. The relationships between production time and delivery time of ships and the independent variables are derived from observed sample data and not based on a deterministic function or a known cause-and-effect mechanism.
(3) It is vital to consider strong theory, measurement error, and specification errors when selecting dependent and independent variables for multiple regression. The variables chosen in this study are based on well-established concepts and theories within the field of shipbuilding and are collected from reliable and valid data sources. A thorough literature study and consultations with experts have ensured that the research model accurately captures the essential aspects of the relationships

between the dependent and independent variables. The data collection process for the variables considered and accounted for both measurement error and specification error.

To investigate the overall Build Location variable, described in section 3.3.4 and 4.2.1, the General Linear Model (GLM) was used instead of the Multiple Linear Regression method. Following the guidance of Hair et al. (2014), the assumptions of GLM were met. As this method were briefly used to investigate the significance of build locations, it is not further elaborated. To further describe the data sample and the chosen variables, the next few sections provide a detailed elaboration.

3.3.2 Data sample and collection

The quantitative data analyzed in this study was obtained from publicly available sources. The primary data sample was collected using the European Shipyards and Maritime Equipment Associations (SEA Europe) website. SEA Europe offers a comprehensive ship database called Sea-web, which consolidates information on ships, shipowners, shipbuilders, fixtures, casualties, port state control, ISM, real-time vessel movements, and port data into a single application (IHS Maritime, 2023).

In Sea-web, various fields and parameters can be adjusted to generate the desired sample of ships. The search results were exported to Microsoft Excel for further sorting and analysis. The initial search and subsequent sorting are documented in Table 3.3. The sample obtained from Sea-web and exported to Excel was sorted based on the country that initiated the production of each ship. 451 PSVs were filtered out upon the removal of vessels without registered keel laying date. The majority of these ships (314) were built in the USA, while the remaining vessels were distributed among other countries, with 1-3 ships per country except for China (14 ships) and Singapore (15 ships). The data sorting proceeded by excluding ships with a Gross Tonnage (GT) below 1000, as expert consultations deemed these vessels too small to fit the scope of commercial PSV shipbuilding.

The data was then manually reorganized to display the country that delivered the ship to the shipowner, with the initial country listed as a hull yard. This information was cross-referenced for each ship in the Sea-web database, where the hull yard is listed. To further refine the dataset, countries that produced fewer than 45 Platform Supply Vessels (PSVs) were excluded. The final data sample showed a decrease from 44 to 6 countries and 2125 to 1322 ships. These data are found in appendix F. Included ships were then sorted into the included countries, so further data collection for multiple regression analysis could be conducted. Section 3.3.4 goes into detail on how the independent variables were operationalized, and how and what additional data that were collected.

"Ship Type" filter	Platform Supply Ship
Delivered TO	202212 (Des 22)
"Fields to display" filter	Name of ship Built Ship type Keel laid Shipbuilder Build location Delivery date GT Order date Length Standard design Yard No.
Sorting and filtering process…	
Results	44 countries → 6 countries 2125 vessels → 1322 ships

Table 3.3 - Data search and sorting

Outliers

Outlier examination is crucial for guaranteeing the integrity of the analysis outcomes. Outliers are observations that stand out from the crowd due to their unique characteristics. The goal is to pinpoint those observations that don't accurately represent the population of the sample, and hence, can potentially be disregarded or removed from the analysis for being unrepresentative. It's crucial to assess outliers within the context of the overall analysis, evaluating the unique insights and information they might offer (Hair et al., 2014)

All the performed analyses' data samples contained outliers as per the definition of Hair et al. (2014). These outliers were identified using bivariate detection methods, particularly by reviewing scatterplots. Some of these outliers can be considered extreme as they were considerably different from the rest of the data. There are instances where external influences can cause significant disruptions, leading to delays in production and delivery times. As Semini et al. (2023) suggest, such factors could be a hull supplier's bankruptcy or, at other times, both customer and shipyard might mutually agree on postponed delivery due to external factors, such as market-related issues. Ideally, to get the most accurate estimates of production and delivery times beetween build locations, it would be best to identify and exclude all of these cases. This could possibly be a time consuming process, investigating the news and other sources on ships in for instance China and Brazil, possibly several years ago. Given the amount of outliers from several different countries and the time restrictions for the master thesis, the outliers were included. The covariates related to the market situation, as explained in section 3.3.4, can perhaps capture some of the distubance of these observations, as some of them could as explained be related to externalities caused by the market. Also, considering how large the sample size is, it is considered unlikely that these outliers will considerably change the outcome of the analyses. However, it's important to bear in mind that the presence of these outliers might potentially affect the results of the multiple regression analyses and slightly increase the share of unexplainable variability. Hence, their potential impact on the analyses should be kept in mind when interpreting the results.

3.3.3 Dependent Variables

Time Performance in the shipbuilding market segment of specialized ships is of upmost importance. Although several performance measurement methods have been introduced in Chapter 2, time is a critical competitive factor in shipbuilding and other ETO markets. **Production Time** and **Delivery Time** directly influence the overall efficiency and profitability of the shipbuilding process and are highly relevant measures to describe the performance of the specialized shipbuilding industry. Both variables are quantifiable and measurable, making them suitable for quantitative analysis methods like multiple regression. These variables can vary based on numerous factors, such as production strategies, workforce skills, and technological capabilities. Longer production and delivery times can affect the reputation of shipyards and increase costs, while shorter times can enhance competitiveness and efficiency. Hence, these variables are of high practical significance in the shipbuilding industry. (Hicks et al., 2000, Moyst and Das, 2005, Pires Jr et al., 2009, Semini et al., 2022, Semini et al., 2023)

Previous studies have used time to measure performance in the shipbuilding industry (Semini et al., 2018, Semini et al., 2022, Semini et al., 2023). This compatibility allows for comparison with prior research and contributes to building a solid body of literature on time as a performance measurement in shipbuilding. Therefore, using production time and delivery time as dependent variables in a multiple regression analysis can effectively describe differences between shipbuilding industries, providing valuable insights for strategic decision-making and industry competitiveness. To operationalize the dependent variables, the reasoning Pires Jr et al. (2009) and Semini et al. (2023) regarding the use of keel laying instead of steel cutting is followed, as presented in Figure 3.2.

DV1 - Production Time (PT) is operationalized by measuring the number of days from the keel is laid until the ship is delivered to the ship owner. The data is gathered from the IHS Sea-Web database and calculated in Microsoft Excel. Delivery date is specified in IHS Sea-web as the date when the ship status changed to "in service/commission."

DV2 - Delivery Time (DT) is measured as the number of days from the ship is ordered until the ship is delivered to the ship owner. The data is gathered from the IHS Sea-Web database and calculated in Microsoft Excel.

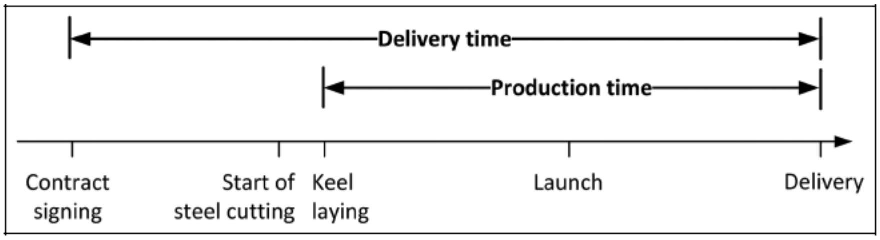

Figure 3.2 - PT and DT measured in this study, developed by Semini et al. (2023)

3.3.4 Operationalization and scoping process of Independent Variables

Ideally, all factors available that can provide information and answers to the research questions should be included. However, a scoping process of the various variables was needed to get operationalized variables for the quantitative analysis. The scoping process was based on findings of the literature study in section 2.4, and further carried out by operationalizing the variables and collecting available data. A simplified description and summary of how this process unfolded is now presented. First, the included independent variables are presented. Then, the included covariates are listed. Lastly, the excluded variables and why they were excluded are described.

The literature study disclosed several factors that affected the production of specialized ships. The findings of the preliminary study indicated how certain factors related to build locations could influence the production and delivery times of specialized ships. Amongst these factors, product volume & variety, proximity to clusters, offshoring, vertical integration, and yard size stood out and were believed to influence PSV shipbuilding times. These factors and other factors are now addressed and investigated further. In addition to the literature investigation in Chapter 2, discussions with supervisors and experts and data examination have led to scoping and operationalizing the factors. If nothing else is specified, the theory provided throughout the rest of this subsection is a summary of what was provided in the Theoretical Background, most often section 2.4. Some of the thought processes of the author are also mentioned, for example when describing why a factor was excluded from further investigation. However, this should not be interpreted as a discussion, but merely subjective assessments of the author at the time. The final included variables are presented in table 3.5.

Independent Variables

Build Location (Industrial Environment)

The industrial environment of the Build Location of a ship, encompassing region-specific factors external to individual shipyards, can potentially influence production and delivery times in the specialized shipbuilding industry. Factors such as labor availability and cost, infrastructure, supply chain efficiency, competitive landscape, economic conditions, and government policies can all contribute to the overall performance of shipyards within a specific country or region. For example, supportive governmental policies, a robust infrastructure, and a skilled labor force can potentially enhance productivity and cost-efficiency, leading to shorter lead times, as found in Chapter 2.4. Conversely, adverse economic conditions or restrictive policies can possibly have the opposite effect, causing longer lead times and increased costs.

Given the conceivable impact of these location-specific factors, this study will operationalize the concept of Build Location by considering each country as a unique entity. In the statistical analysis, this means that industrial environment is a categorical variable called "Build Location". Also, for all other analyses models the variables will be operationalized by keeping the country stable, to keep the industrial environment of the analyzed PSVs similar. This approach ensures that the factors specific to each location's industrial environment are treated as constant when comparing PSV shipbuilding times. However, to provide support for this hypothesis, the variable of Build Location must first be investigated on how it effects production and delivery times of PSVs. The different countries are given separate numbers, where China is the reference variable for comparison. The country's number-values in the regression analyses are presented in Table 3.4.

Country	Value
Brazil	1
China, the People's Republic of	2
India	3
Netherlands	4
Norway	5
The United States of America	6

Table 3.4 - Build Location categorical variable values

Proximity to Cluster

Porter (1998) explain how being part of a cluster allows for communication and coordination between companies, driving improvements and benefits of scale while maintaining flexibility. This can facilitate outsourcing parts of production while mitigating some of the effects that can be lost from not vertically integrating parts of production. It was considered interesting to investigate whether being part of a cluster could affect the production and delivery time of specialized ships delivered. While clusters can enhance the efficiency and performance of shipyards through cooperation and shared learning, assessing the impact of clusters requires a nuanced understanding of regional factors and industry dynamics. Data collection challenges, such as changes in the number of shipyards and related companies over time, could introduce undue variance or insignificance.

The PSVs delivered from China were chosen as the sample for the Proximity to Cluster variable to maintain a large data sample, while assuring that the ships were built in the relatively same industrial environment. Also, the Chinese shipbuilding industry are known for its large clusters (OECD, 2021). Still, the large number of Chinese shipyards delivering PSVs make for a diversified sample with shipyards both part of a cluster and shipyards not part of a cluster. The data was collected from public sources like Peer Reviews (OECD, 2021) and the internet. All shipyards were assessed on google maps to see if they were located near other shipyards and equipment manufacturers. Note that the data collection process does not consider the size of the cluster or the number of aspects of the shipbuilding supply chain that are included in the cluster. The operationalization neither considers the degree of design offshoring or vertical integration of design related to the ship. The variable is binary, where the ship is given the value 1 if it is a part of a cluster, and 0 if not.

Hull Offshoring

Offshoring certain aspects of a shipbuilding project is a strategic decision that some companies use. This has been common in for example the Norwegian and Dutch shipbuilding industries, where parts of a ship like the steel hull is offshored to countries with lower labor costs (OECD, 2017, OECD, 2020). Some recent papers have been published on the offshoring of hull production in the Norwegian and European shipbuilding industries (Semini et al., 2018, Semini et al., 2022, Semini et al., 2023). Offshoring a part of the ships production process is often related to the industrial environment of a ship's build location. As an example, offshoring the hull of a ship is a strategy frequently applied when the country of the shipyard has high labor costs and expensive material costs. The research of Semini et al. (2022) suggest offshoring is strongly linked to production time performance, based on 76 ships delivered from Norwegian shipyards.

As seen in Table 2.6, offshoring consists of several aspects. In this study however, Offshoring is primarily considered the process described as hull production offshoring and offshoring of design. Offshoring of outfitting work, level of integration of hull yard and offshoring of engineering work, are not included due to data collection difficulties and related time constraints. Data examination of ships that had their hull production offshored was done by investigating each ship built in Poland, Turkey, Germany, Romania, Ukraine, Norway, and Netherlands, to see whether the hull production of a ship was performed in other countries than given in the excel sheet. Every ship was investigated in Sea-Web to examine which yard was listed as the "hull yard", and which shipyard that was listed as the builder of the rest of the ship. The results were that the number of ships delivered from several countries such as Turkey, Ukraine, Poland, Germany, and Romania were drastically reduced or entirely removed. The ships were built in either Norway or the Netherlands, and the above countries were only involved in the hull production. As these countries also were specific countries found in the literature, and both had a relatively large data sample, they were chosen as the representative countries for the statistical analysis. The hull offshoring variable is operationalized by a binary variable, where the value equals 1 when a ship has been offshored, and 0 otherwise.

Design Offshoring

Offshoring of design capabilities are similar to hull offshoring. Instead of the production of the hull being offshored, it is the design of the ship that is contracted to an external design company in another country. The reasons for using a company in a different geographical location for design are not necessarily related to cost efficiency, as with hull offshoring, but can rather be about securing the expertise and technological advancements of ship designers. Some authors have investigated the effect of design on shipbuilding competitiveness and performance (Haartveit et al., 2012, Ebrahimi et al., 2021a). However, this study aims to investigate the effect of offshoring the design of a PSV on production and delivery times.

When investigating the PSVs delivered from Chinese shipyards, it was discovered how there was differences in the countries of origin of the design companies tied to the ships. Data on design outsourcing was gathered by collecting data on the shipyards and ship designs provided in Sea-Web. The author searched on google to see if a shipyard had an integrated design department, and if the ship design information from Sea-Web implied that the ship was designed from that department or not. The ships that were built with integrated designs were removed to not interfere with the Vertical Integration of Design model. Ships with outsourced design from Chinese design companies, Asian design companies or design companies from the rest of the world were included. When using the formulation "design companies", it is also referred to the design departments of shipyards. The variable was operationalized by giving ships produced with Chinese design the value 0, ships with Asian design the value 1, and the ships with design from the Rest of the World the value 2.

Vertical Integration of Design

The qualitative analysis performed in the specialization project showed, amongst other things, that the degree of Vertical Integration of a shipyard seemed to influence a ship's production and delivery time. Vertical integration is the degree of which a company has integrated several aspects of the supply chain into its core business. Such aspects of the supply chain could be the equipment vendor, design company, ship owner or others. Parts of the supply chain that can be vertically integrated or outsourced, and which the literature seems to imply that can influence the production and delivery time of specialized ships, are equipment manufacturing and especially design capabilities.

Vertical integration is an essential aspect of Lamb and Hellesoy (2002) research, as it represents the extent to which a shipyard controls its production processes, from design to final assembly. In their study, the authors assess vertical integration by considering how much of the shipbuilding work is carried out in-house compared to what is outsourced. As described in chapter 2.4, they argue that a higher degree of vertical integration can lead to increased productivity and better control over production processes. However, they also note that it might not be the best strategy for all shipyards, as it can limit flexibility and increase fixed costs. It could be highly interesting to investigate if this aspect could be a strategic choice that will result in a change in the production and delivery times of PSVs.

To operationalize and investigate Vertical Integration, one must define to what degree a shipyard is vertically integrated and what aspects of the theme that can be of focus. To keep the region-specific production characteristics industrial environment of the sample as similar as possible, and still maintain a large data sample for the statistical analysis, ships delivered from China and Norway were chosen as the data sample. The literature revealed two main aspects of Chinese production within vertical integration, equipment manufacturing integration and design capabilities within the shipyards. Equipment manufacturing was traditionally outsourced, and Chinese shipbuilders used to buy from foreign suppliers. This has changed as the industry has developed, and equipment manufacturing have been integrated into the Chinese shipbuilding industry during the 2000s (Tsai, 2011, OECD, 2021). This can be tricky and time-consuming to operationalize. One must consider how the equipment manufacturing situation have been for each ship, which when the data is different over time is difficult to obtain.

Integration of design capabilities were possible to collect data on. The literature showed that this aspect could affect production and delivery time of specialized ships due to, for instance, issues related to collaboration between shipyards and external design companies (Haartveit et al., 2012). The variable was operationalized by investigating whether the ships design company was integrated into the shipyard or acquired from an external company. For both Chinese and Norwegian shipyards, the ship design and shipyard provided in Sea-Web were investigated. Data on design companies and design departments of shipyards were available on the internet and was collected for all the Norwegian and Chinese PSVs. The variable is given the value 0 if the design of a ship was performed by an external design company, and the value 1 if the design was from an integrated design department. If the ship's hull production or design were not from a domestic company, the ship was excluded from the sample, to not be disturbed by possible effects of hull- and design offshoring.

Covariates

Certain factors derived from the literature is important additions to the study as covariates. These covariates are added to the analyses to be able to investigate the relationship between the dependent and independent variables, without the disturbance of these externalities. Ideally, several covariates should be included to account for all potential influence of externalities. Still, these four factors are highlighted in the literature and seem to be especially relevant for this study, and data on these are available. The covariates and their operationalization will now be presented.

Ship size

Ship size, measured in Gross Tonnage (GT), plays a pivotal role in shipbuilding production, significantly impacting production and delivery times due to the inherent logistical and transportation complexities associated with larger vessels. The size of a ship directly correlates with the volume of work required per ship, considering factors such as steel structure and outfitting. In this study, the Ship Size variable has been operationalized using data obtained from the IHS Sea-Web database, on the registered Gross Tonnage of each ship. It is hypothesized that as the size of the ship increases, so does the production and delivery time. To ensure the validity of the study, the data has been adjusted to include only ships above 1000 GT, ensuring the ship sizes are in correlation with the types of vessels being investigated. Controlling for Ship Size ensures that observed time-performance variations are not merely a direct effect of differences in ship sizes but are indeed influenced by other factors being studied. Thus, ship size is a critical consideration in this research, contributing to our understanding of production and delivery times in shipbuilding. This aspect was highlighted in a study by Semini et al. (2023), who investigated the effect of ship size on the production and delivery time of Offshore Support Vessels (OSVs). They found a significant relationship, emphasizing the necessity to adjusting for ship size when analyzing shipbuilding production and delivery times.

Supply situation

The market situation in the shipbuilding industry can play a pivotal role in affecting the production and delivery times of specialized ships. As described in chapter 2.4, it is not only about the state of the market supply and demand, but also the resultant ripple effects that can influence the whole production cycle. Semini et al. (2022) highlight that high demand can cause increased shipbuilding activities, which can strain resources. As this can potentially lead to scarcity of materials, equipment, and workforce, it thereby can increase shipyards production and delivery times. Because of these findings, the market situation variable will operate as a covariate, which ensures that the variation in production and delivery times is not just an effect caused by fluctuations in the market.

When calculating the supply- and demand situation, all 2125 ships from all 44 countries were included to capture the whole market situation. To operationalize the supply situation in this study, the focus will be on the order date of the ship. If a ship were delivered in June or earlier, the average number of ships contracted in the order year and the preceding year is calculated. Conversely, if the ship was delivered in July or later, the average number of ordered ships for that year and the following year will be calculated. This approach reflects the market situation at the time of the ship's order date and the immediate period before or after. Favorable market situations could potentially both increase and reduce production and delivery times, as empirical findings by Semini et al. (2022) suggest a complex relationship.

Demand Situation

The reasoning provided above is also relevant in this section. The demand situation is critical as it makes sure the variations in production and delivery times are not just a direct effect of the market demand being better or worse. The findings of Semini et al. (2022) implicate that production and delivery times are reduced in periods of good market times. The Demand Situation covariate is operationalized by measuring the average number of ships that are delivered in the ships production period, from the keel laying date to the delivery date of a ship.

Delivery year

Mickeviciene (2011) and Hossain and Zakaria (2017) describe how growth and trends in the shipbuilding industry has varied and developed over time. As an example, Kretschmer (2012) explain how the implementation of ICT seem to have increased productivity over time. It is reasonable to believe that assessing the different years of specialized shipbuilding could perhaps show that certain factors such as technology, industry development, and learning over time has affected shipbuilding productivity. Including the covariate of delivery year makes sure the variations in production and delivery times are not just a direct effect of how technological progress and general improvements impacts and reduces building times of PSVs. Conversely, it assures that increased shipbuilding times are not just an effect of how more technologically advanced and complex ships create more time-consuming processes. Thus, Delivery Year operates as a covariate for the analyses. The Delivery Year covariate is operationalized by using the delivery date of a PSV listed in Sea-Web. As years are an increasing metric, it can be used as a "scale" in the Multiple Regression Analysis.

Excluded variables
The factors and variables that are not further investigated in the multiple regression analyses are now presented.

Overlapping between engineering and production
Semini et al. (2023) explain how overlapping between engineering and production can reduce the production and delivery time of a ship. Overlapping engineering and production could cause difficulties as well, such as challenges in cost calculations, planning and coordination, and can lead to rework due to design errors and changes. As Semini et al. (2023) analyze the production of OSVs delivered from European shipyards, they find that overlapping engineering and production seem to be independent of time performance in shipbuilding. Due to these recent findings, performed using a similar statistical analysis on a similar data sample, this aspect will not be further investigated in this study.

Facilities and Transportation capacity
As Pires Jr et al. (2009) state, facilities and capacity can affect the building time of ships. Shipyards have different solutions regarding the choice of facilities, transportation methods, and capacity. However, it is not a permanent constraint and can be expanded at moderate costs. Collecting data on the different yards and their change in facilities and transportation capacity over the years would however be very time-consuming. The change at shipyards over time would take a lot of work to consider. Thus, because of the time constraints of the master thesis project, it is not included in this study. Some of the aspects of facilities and transportation capacity is mentioned in the Yard Size/Capacity section.

IT, manufacturing technology and theory
Information Technology (IT), manufacturing technology, and theory are pivotal elements in the shipbuilding industry, profoundly influencing production and delivery times of specialized ships. Assessing technological and managerial capabilities are critical when investigating the level of competitiveness of a shipyard (Pires Jr et al., 2009). IT can play a crucial role in ship design, production planning, and supply chain management. Manufacturing technology influences the efficiency and quality of production processes, while theory can offer insights into optimal production strategies and techniques. However, collecting comprehensive data on these aspects for each shipyard and tracking changes over time can be a challenging task. It would involve extensive data collection efforts and require access to proprietary information that may not be publicly available or is not shared by the shipyards due to competitive reasons. Furthermore, the rapid pace of technological change means that data can quickly become outdated, complicating longitudinal studies. Therefore, despite their importance, these aspects will not be included in this study due to practical constraints. This limitation does not diminish the potential impact of IT, manufacturing technology, and theory on shipbuilding time-performance, and future studies may aim to explore these relationships further.

Product variety, customization and repeat production

Product variety in shipbuilding can have significant implications on production and delivery times of specialized ships. According to Pires Jr et al. (2009) and Semini et al. (2022), there are benefits to producing multiple identical ships, including the influence of worker experience, simplification and learning growth of design processes, and the ability to reuse documentation. Such factors can positively impact man-hour consumption, efficiency, and production times. Semini et al. (2022) specifically analyzed the production of OSVs in Europe, and found that repeat production significantly reduced production time, although this effect was dependent on the specific build strategy employed. The repeat production factor was briefly considered and operationalized for this study. The PSVs delivered from a shipyard was given a value dependent on when it was produced. For example, if a ship was produced as the third PSV delivered from that shipyard, it was given the value 3. Then, the variable was transformed into the natural logarithmic value, as it was believed that the effects of repeat production is likely to decrease as a ship's position in the series increases (Erichsen, 1994, OECD, 2007, Semini et al., 2022). However, the variable was not significant for any of the analyses models and was excluded from further investigations. Including variables that don't contribute to the explanatory power of the model can unnecessarily increase the complexity of the model and reduce the degrees of freedom (Hair et al., 2014). It is therefore not mentioned in table 3.3 and chapter 4. Product variety and customization are not further investigated in this study. This decision stems from various reasons, including data limitations, time constraints, and the focus on other potentially more impactful variables. It's worth noting, however, that the role of product variety and customization in shipbuilding production is an important consideration and could be beneficially explored in future research.

Ship complexity

Ship complexity, as defined by the complexity of design and the volume of materials such as steel and pipes used, is often considered a significant determinant of production and delivery times in shipbuilding. The greater the complexity, the more extensive the preparation, design, assembly, and installation work could be. This could, in theory, prolong the production and delivery times of specialized ships. However, a study conducted by Semini et al. (2022) investigated the impact of ship complexity on shipbuilding, and their findings suggest that the complexity does not significantly affect the production time. This lack of correlation might seem counterintuitive, but it may be attributed to the homogeneity and similarity in complexity among the specific type of vessels under examination in Semini et al. (2022).

Considering these findings and the specific scope of the current study, it was decided not to include ship complexity as a variable. This decision is based on the expectation that PSVs under investigation share a similar level of complexity, thus reducing the probability for variance in production and delivery times due to this factor. This decision contributes to the focus and relevance of the study, allowing for a more precise analysis of the other factors influencing PSV shipbuilding times.

Yard size/capacity

The capacity or yard size of a shipbuilding facility can critically influence the production and delivery times of specialized ships. Yard size or capacity can be assessed through various parameters as described in section 2.4, including production capacity, asset turnover, physical facilities, and workforce. While the measurement of these parameters can provide valuable insights into the effects of yard size on time performance, the process of data collection and analysis can be complex and time-consuming. To see if these challenges could be bypassed, the ships built in China was chosen as the data sample. This was due to the fact that China has a large number of shipyards, at several different sizes.

Measuring yard capacity in terms of workforce and turnover could present challenges, especially in contexts where employment contracts are time-limited and a large proportion of the workforce is temporary or sub-contracted as they are in China (Varela et al., 2017). Also, available information on number of workers and turnover of Chinese yards over the years are poor. It was considered measuring yard size by assessing the physical facilities of the shipyards in China from google maps. However, this would be a greatly time-consuming process and again the time constraints of the master thesis project were an inhibitor for this data collection process. This also presents several challenges as the pictures on google maps provide little info on where a yard's physical area starts and ends, what is included, and what is the start of the yard next to it. Thus, this could leave room for a lot of human error in the data collection process and could result in incorrect measurements and calculations. A yard could also be different at the time of ship production compared to what is shown in google maps today. This could be a future research project for data collection trough a survey sent to shipyards, which could contain other information, similar to what is done by Pires Jr et al. (2009).

It was also considered focusing on using a more manageable measure of yard capacity, as the number of ships produced at a yard. This approach is inspired by Colin and Pinto (2009) and was considered due to its simplicity and the availability of data through public sources like Sea-Web. However, this operationalization of yard capacity might not capture all the nuances of yard size and capacity, and as such, it could risk not capturing the essence of the variable. Further difficulties with operationalization of the variable are how one adjusts for ship size and difference in complexity between ships. How this could be done was considered, but eventually yard size/capacity was ruled out of the included variables due to the difficulty and time constraints of the operationalization process. Future research could consider more comprehensive measures of yard capacity, perhaps using survey methods or collaborations with shipyards to gain access to more detailed and accurate data.

Variable	Variable type	Measure
Dependent variables		
The ship's production time (PT)	Metric	Number of days between keel laying date and delivery date Delivery date is specified in IHS Sea-Web as the date when the ship's status is changed to "in service/commission"
The ship's delivery time (DT)	Metric	Number of days between contract signing date and delivery date
Independent variables		
Build Location (BuildLocation)	Categorical	Country of shipyard
Proximity to cluster (Cluster)	Binary	Value = 1 if shipyard is part of cluster, value = 0 otherwise 454 PSVs built at Chinese shipyards
Hull offshoring (Offshored)	Binary	Value = 1 if hull is offshored, value = 0 otherwise 273 PSVs built at Norwegian shipyards and 45 PSVs built at Dutch shipyards
Design offshoring (OffDes)	Binary	Value = 0 if design is from a Chinese design company, value = 1 if design is from asian company and value = 2 if design is from the rest of the world 257 PSVs built at Chinese shipyards
Vertical Integration of design (VertInt)	Binary	Value = 1 if design capabilities are integrated at yard, value = 0 if external Chinese design company is used 250 PSVs built at Chinese shipyards
Covariates / control variables		
Delivery year (DelYear)	Metric	The year a ship is delivered 2125 PSVs delivered from 44 countries
Supply situation (SupplySit)	Metric	Average contracted PSVs of the year a ship is produced and the year before/after, dependent on if the ships was produced before/after the month of july 2125 PSVs delivered from 44 countries
Demand situation (DemSit)	Metric	Average yearly contracted number if ships between keel laying and delivery date 2125 PSVs delivered from 44 countries
Ship Size (ShipSize)	Metric	Registered Gross Tonnage (GT) of ship

Table 3.5 - Included Variables

3.3.5 Research models

The scoping and operationalization of the variables helped form the overall research models for the multiple regression analysis. The overall models are split into model A and model B, for the dependent variables of production and delivery time, respectively. Model A and Model B are references for several smaller analysis models, investigated in chapter 4. These anlayses models are the Build Location model, Proximity to Cluster model, Hull Offshoring model, Design Offshoring model, and the Vertical Integration of Design model.

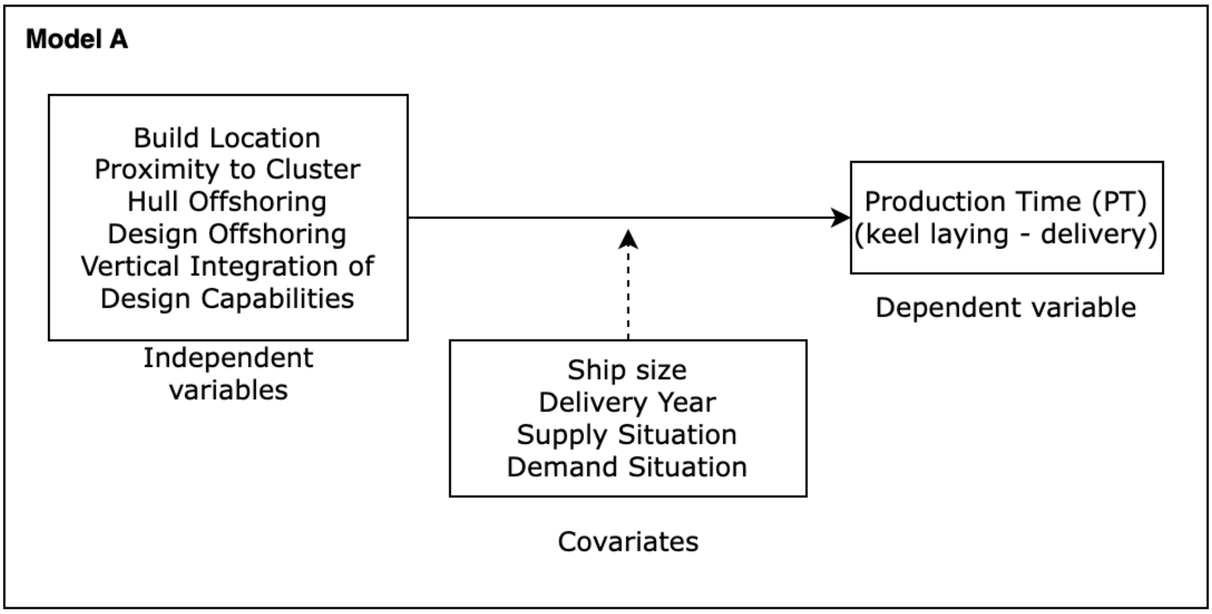

Figure 3.3 - Research Model A

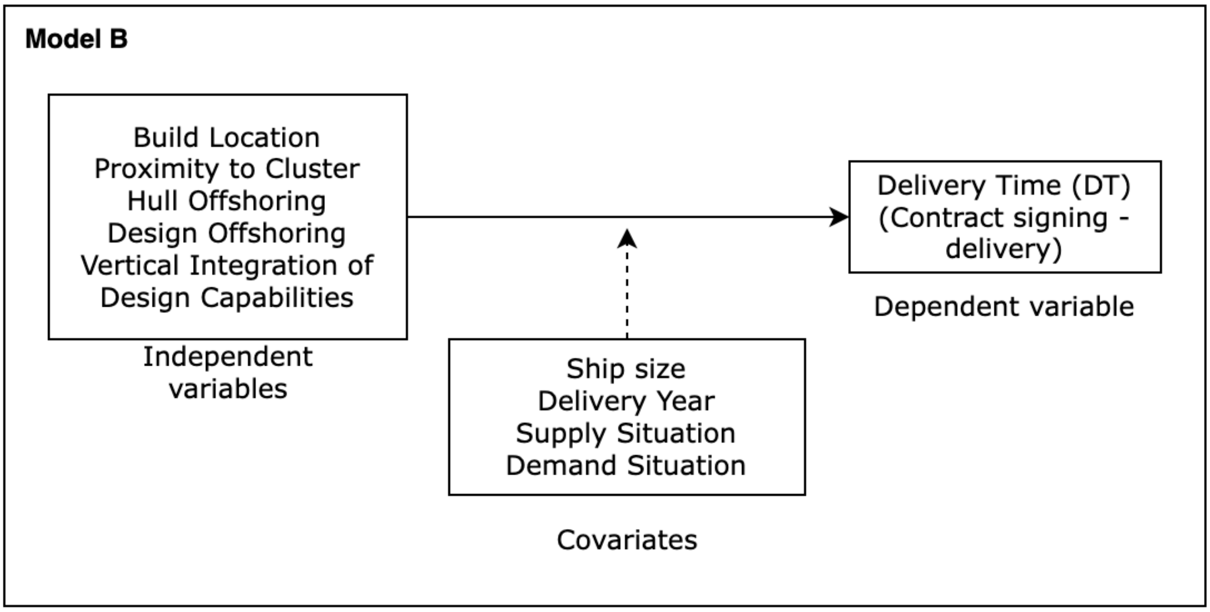

Figure 3.4 - Research Model B

3.3.6 Hypotheses

The overall research model presents several independent variables predicted to influence the dependent variables of production time and delivery time. A hypothesis can be defined for each of these independent variables' connection with the dependent variables. These independent variables are ultimately a result of the findings of the preliminary study and the literature study. In other words, the variables are rooted in theory from the literature. The model aims to substantiate the relationships found in the literature, and the hypotheses are formulated as a result of these findings.

A null hypothesis and an alternative hypothesis was developed for each of the independent variable's relationship with one of the dependent variables to test the relationships. However, for simplicity, the null hypothesis will only be stated for the first hypothesis in question. $H_{0\text{-}I}$ will operate as an example, and the rest of the null hypotheses are the same as the first one, only with different variables. The independent variables are given in the alternative hypotheses below, and the dependent variables are differentiated by providing the hypotheses a notation of "A" for production time and "B" for delivery time.

One of the first findings of the preliminary study was that regional-specific factors appeared likely to influence the production and delivery time of specialized vessels. When the formulation "ships" is used in the hypotheses, it is referred to PSVs. Based on the literature, the first null hypotheses are created:

$H_{0\text{-}IA}$: *"There is no relationship between the Build Location of a ship and the ship's production time."*

$H_{0\text{-}IB}$: *"There is no relationship between the Build Location of a ship and the ship's delivery time."*

The alternative hypotheses can be developed:

$H_{1\text{-}IA}$: *"The production time of a ship is related to the Build Location of a ship."*

$H_{1\text{-}IB}$: *"The delivery time of a ship is related to the Build Location of a ship."*

Based on the review of the literature and the factor scoping process described in section 3.3.4, it was identified that a shipyard's proximity to a cluster, offshoring of hull production and design, and vertical integration of design capabilities might explain some of the differences in production and delivery time between the build locations. Therefore, the alternative hypotheses were made and are presented in table 3.5.

Notation	Model	Alternative hypothesis
$H_{1\text{-}IIA}$	Cluster Model	*"The production time of a ship is related to the shipyard's proximity to a cluster."*
$H_{1\text{-}IIB}$	Cluster Model	*"The delivery time of a ship is related to the shipyard's proximity to a cluster."*
$H_{1\text{-}IIIA}$	Hull Offshoring Model	*"The production time of a ship is related to whether the shipyard offshores hull production or not."*
$H_{1\text{-}IIIB}$	Hull Offshoring Model	*"The delivery time of a ship is related to whether the shipyard offshores hull production or not."*
$H_{1\text{-}IVA}$	Design Offshoring Model	*"The production time of a ship is related to whether the shipyard offshores design capabilities or not."*
$H_{1\text{-}IVB}$	Design Offshoring Model	*"The delivery time of a ship is related to whether the shipyard offshores design capabilities or not."*
$H_{1\text{-}VA}$	Vertical Integration of Design Model	*"The production time of a ship is related to the degree of vertical integration of design capabilities at the shipyard."*
$H_{1\text{-}VB}$	Vertical Integration of Design Model	*"The delivery time of a ship is related to the degree of vertical integration of design capabilities at the shipyard."*
$H_{1\text{-}VIA}$	All Models	*"The production time of a ship is related to the Ship Size of the ship."*
$H_{1\text{-}VIB}$	All Models	*"The delivery time of a ship is related to the Ship Size of the ship."*
$H_{1\text{-}VIIA}$	All Models	*"The production time of a ship is related to the Delivery Year of the ship."*
$H_{1\text{-}VIIB}$	All Models	*"The delivery time of a ship is related to the Delivery Year of the ship."*
$H_{1\text{-}VIIIA}$	All Models	*"The production time of a ship is related to the Supply Situation of the ship."*
$H_{1\text{-}VIIIB}$	All Models	*"The delivery time of a ship is related to the Supply Situation of the ship."*
$H_{1\text{-}IXA}$	All Models	*"The production time of a ship is related to the Demand Situation of the ship."*
$H_{1\text{-}IXB}$	All Models	*"The delivery time of a ship is related to the Demand Situation of the ship."*

Table 3.6 - Alternative hypotheses

4 Analysis and Results

This chapter presents the findings of the data analysis. The use of Multiple Regression Analysis in this study is detailed and the underlying assumptions are explored. The chapter aim to provide an objective, holistic view of the data analysis results. The chapter culminates in the testing of our proposed hypotheses. The regression analyses are performed with the statistical software, IBM SPSS Statistics version 27 0.1.0, a platform that is equipped with the necessary tools for conducting regression analyses and producing graphs and figures.

4.1 Preliminary examination

In the following sections, the independent and dependent variables are examined individually and in pairs of two. Tasks involved in examining data are an essential part of any multivariate analysis (Hair et al., 2014).

4.1.1 Univariate examination

Univariate data examination is the starting point for understanding the nature of the variables by characterizing the shape of its distribution (Hair et al., 2014). This can be done by examining graphs of data, such as histograms. The frequency histograms of the variables in all models will now be discussed briefly. The histograms are found in appendix C, under the section "Histograms".

Build Location variable distributions

The descriptive statistics for the continuous variables included in the Build Location model are presented in table 4.1. Figure 4.1 present the number of ships built at shipyards located in the different countries included in the analysis, and the countries' market share percentage.

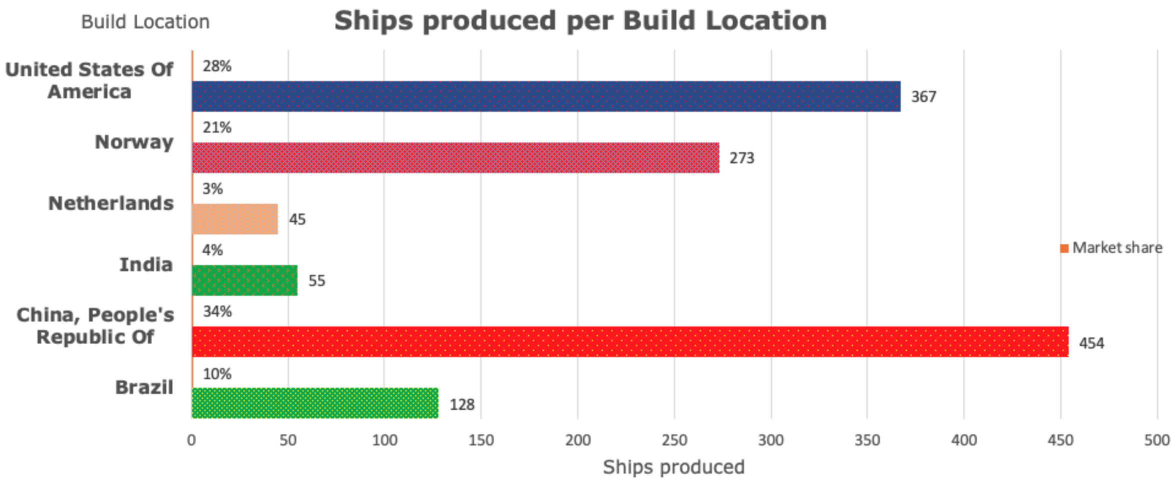

Figure 4.1 – Number of ships produced and market share per build location

Figure 4.2 showcases how many PSVs that have been delivered from the different build locations per year. Out of the 1322 ships included in the analysis, India and Netherlands have the lowest shares. The People's Republic of China and United States of America has produced a lot more ships and are overrepresented in the variable. Ideally, the ships could be evenly distributed amongst the different Build Locations in the categorical variable.

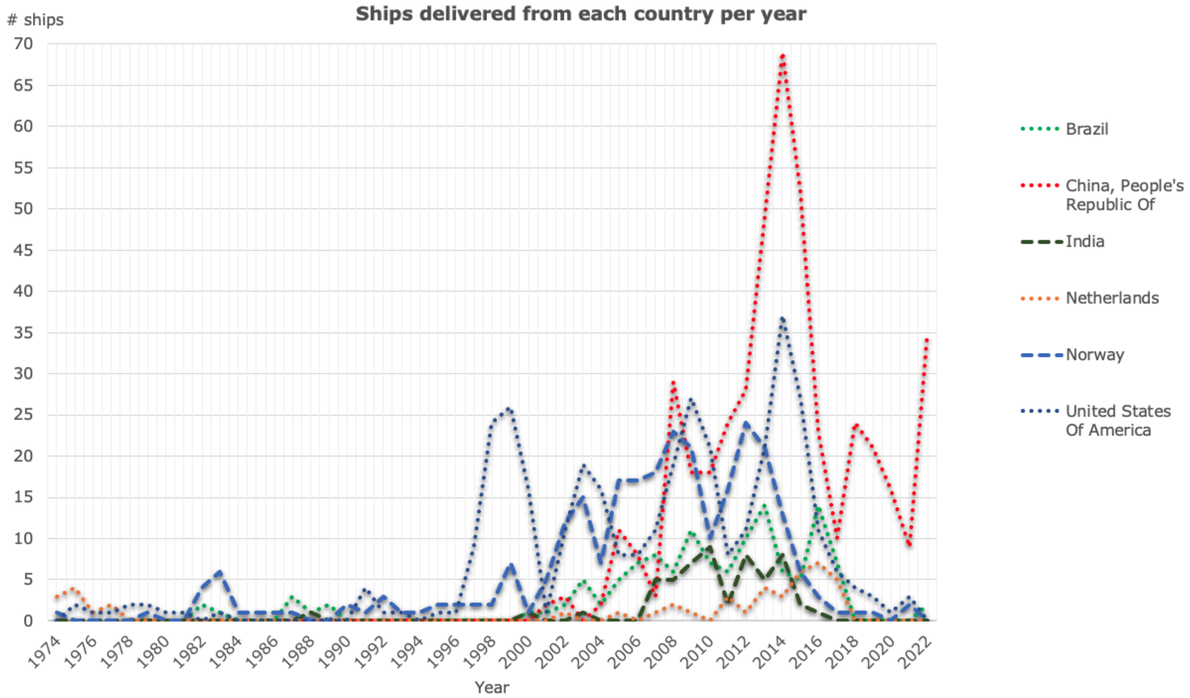

Figure 4.2 - Number of ships delivered from a build location each year

The histograms for the variable distributions of the build location model are presented in appendix C and show few surprises. Examining them individually show how, for example, the number of ships delivered increased until 2014, approximately at the time of the oil price drop, before it then started to decrease.

Model		Variable	Min	Max	Mean	Std. Deviation
Build Location	Dependent variables	PT	61	3195	618.34	520.624
		DT	212	5388	1000.45	583.231
	Covariates	ShipSize	1004	8417	2921.79	1178.862
		DelYear	1974	2022	2009.35	8.177
		SupplySit	2	185	109.97	56.166
		DemSit	3	165	88.33	41.356

Sample size = 1322

Table 4.1 - Descriptive statistics for Build Location

Proximity to cluster variable distributions

The descriptive statistics for the variables included in the Cluster model are presented in Table 4.2. The sample size for this model is 454 ships, all built in China, leaving the variable distributions of this model somewhat changed from the Build Location model. The histograms of the variable distributions are presented in appendix C.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
Proximity to cluster	Dependent	PT	153	3195	765.23	721.139
		DT	275	3684	1143.94	753.037
	Covariates	ShipSize	1053	7683	2975.86	974.922
		DelYear	2001	2022	2013.98	4.477
		SupplySit	7.0	166.5	124.764	43.5669
		DemSit	19	165	102.87	38.682
	Independent	Cluster	0	1	.59	.492

Sample size = 454

Table 4.2 - Descriptive statistics for Proximity to cluster

Hull Offshoring variable distributions

The descriptive statistics for the variables included in the Hull Offshoring model on Norwegian PSVs are presented in Table 4.3. Of the 273 ships delivered from Norwegian shipyards 191 had their hull production offshored, where the majority share was delivered after the year 2000. The histograms of the variable distributions are presented in appendix C.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
Hull Offshoring	Dependent	PT	151	2648	417.87	259.099
		DT	212	2801	732.64	345.281
	Covariates	ShipSize	1202	8414	3433.77	1200.711
		DelYear	1974	2021	2006.08	8.002
		SupplySit	3.5	166.5	94.110	48.9765
		DemSit	3.0	165.0	75.71	37.53
	Independent	Offshored	0	1	0.70	0.459

Sample size = 273

Country = Norway

Table 4.3 - Descriptive statistics for Hull Offshoring on Norwegian PSVs

Table 4.4 presents the descriptive statistics for the Hull Offshoring model, but for the ships delivered from Dutch shipyards. The sample size is a lot smaller than shown in table 4.3, where 12 of the 45 ships delivered from Dutch shipyards had their hull production offshored.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
Hull Offshoring	Dependent	PT	92	1217	450.60	291.341
		DT	243	1492	855.29	329.631
	Covariates	ShipSize	1104	6422	2593.78	1424.561
		DelYear	1974	2017	2004.82	16.349
		SupplySit	9.5	166.5	106.23	54.356
		DemSit	12	159.5	86.63	43.892
	Independent	Offshored	0	1	.27	.447

Sample size = 45

Country = Netherlands

Table 4.4 - Descriptive statistics for Hull Offshoring on Dutch PSVs

Design Offshoring variable distributions

The descriptive statistics for the variables included in the Design Offshoring model are presented in Table 4.5. The histograms of the variable distributions are presented in appendix C. Out of the 257 PSVs included in the analyses are ships built at Chinese shipyards, 78 were built with design from Chinese companies, 40 with design from Asian companies, and 139 with design from companies located in other countries.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
Design Offshoring	Dependent	PT	153	3195	779.20	717.189
		DT	334	3468	1206.59	751.874
	Covariates	ShipSize	1092	7683	3223.67	936.251
		DelYear	2002	2022	2013.92	4.248
		SupplySit	15	185	142.28	42.248
		DemSit	28	165	108.64	38.154
	Independent	OffDes	0	2	1.24	0.889

Sample size = 257

Country = China

Table 4.5 - Descriptive statistics for Design Offshoring

Vertical Integration of Design variable distributions

The descriptive statistics for the variables included in the Vertical Integration of Design model are presented in Table 4.6. The histograms of the variable distributions are presented in appendix C. Out of the 250 Chinese PSVs included in the analysis, 49 had the design capabilities integrated at the shipyard, while 201 PVS were built with outsourced design from external Chinese design companies.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
VI of design	Dependent	PT	153	3195	732.42	770.657
		DT	275	3529	1043.19	782.251
	Covariates	ShipSize	1053	5361	2661.02	960.150
		DelYear	2001	2022	2013.85	4.924
		SupplySit	7.0	166.5	115.074	48.6992
		DemSit	19	165	96.70	39.854
	Independent	VertInt	0	1	.80	.398

Sample size = 250

Country = China

Table 4.6 - Descriptive statistics for Vertical Integration of Design on Chinese PSVs

Table 4.7 shows the descriptive statistics for Vertical Integration of design, but for the ships delivered from Norwegian shipyards. 13 of the 82 ships were built at a shipyard with vertically integrated design capabilities.

Model	Variable type	Variable	Min	Max	Mean	Std. Deviation
VI of design	Dependent	PT	151	1887	346.70	208.793
		DT	212	1979	707.83	363.059
	Covariates	ShipSize	1202	8414	3202.27	1371.788
		DelYear	1974	2019	2000.41	11.221
		SupplySit	3.5	166.5	73.12	55.091
		DemSit	3.0	159.5	59.14	40.925
	Independent	VertInt	0	1	.84	.367

Sample size = 82

Country = Norway

Table 4.7 - Descriptive statistics for Vertical Integration of Design on Norwegian PSVs

4.1.2 Bivariate examination

The bivariate data examination is to examine and understand the relationship between two variables (Hair et al., 2014). This can be done by examining graphs of data, such as scatterplots, or investigating the correlation coefficients. Appendix D provides Pearson's correlation coefficients for the variables in the analysis models. These numbers explain the degree of which a variable is correlated with another variable. As we recall from chapter 2.5.2, if variables are correlated, it can cause multicollinearity. As Field (2013) suggest, correlation-values over 0.80 can indicate correlation and multicollinearity. As seen from the correlation matrixes in appendix D several values over have some degree of correlation. The correlation between SupplySit and DemSit are even over the noticeable value of 0.80 for the Hull Offshoring model. However, when two covariates like this correlate, it might not be so alarming, as we do not intend to investigate their specific regression coefficients. Also, Hair et al. (2014) explains how examining the variables VIFs and tolerance-values can also provide valuable information when assessing collinearity and investigating multicollinearity. The variable's tolerances and VIFs can be investigated in the assumption investigation in section 4.2.2, where possible correlations and multicollinearity will be further elaborated on.

4.2 Regression calculations

In the following subsection, the outcomes from the regression analyses are described and the integrity of the analytical process is evaluated.

4.2.1 Models

The overall research models Model A and Model B, as presented in section 3.3.5, consist of several independent variables and covariates that aim to explain the dependent variables. Several analyses models were developed in order to examine the different factors. Every analysis model consists of one of the independent variables, one or more of the covariates, and one of the dependent variables. The results of these models are now presented for both production and delivery times.

Build Location

The model summaries are described in Table 4.8 and Table 4.9. Model A is summarized as:

Model A, PT: $F(9, 1312) = 120.95$, $p < 0.001$, with $R^2 = 0.453$ and adjusted $R^2 = 0.450$. The model was significant at the 0.001 level (p-value).

Model B is summarized as:

Model B, DT: $F(9, 1312) = 70.73$, $p < 0.001$, with $R^2 = 0.327$ and adjusted $R^2 = 0.322$. The model was significant at the 0.001 level (p-value).

The coefficient of determination (R^2) is relatively high for both models. The adjusted R^2-values explains the level of variance of the models, or the total effect that the independent variables have on the dependent variables of the model. As seen, the value of "Adjusted R Square" is 0.45 and 0.32, which means that the model can explain approximately 45% of the variance in PT and 32% of the variance in DT, respectively.

Table 4.8 and Table 4.9 are the regression results of the Build Location models. The values most worth noticing, which are included in the tables, are the regression coefficients (B) and standardized regression coefficients (Beta), the *p-values* (which are the significance levels), and the *Part correlation*. The regression coefficients B and Beta, denote the alterations in the dependent variable corresponding to each unit shift in the independent variables. The p-values are listed in the "Sig."-column and represent the statistical significance of the variable. The *part correlation* is a value worth noticing, as it represents the unique effect of each independent variable. (Hair et al., 2014)

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.453	0.450
ShipSize	0.059	0.133	< 0.001	0.111		
DelYear	36.087	1.892	< 0.001	0.389		
SupplySit	3.372	0.364	< 0.001	0.219		
DemSit	-9.875	-0.784	< 0.001	-0.480		
BuildLocation			< 0.001			
Brazil	-110.360	-0.063	0.006	-0.057		
India	209.966	0.081	< 0.001	0.077		
Netherlands	-95.328	-0.033	0.126	-0.031		
Norway	-247.547	-0.193	< 0.001	-0.150		
USA	-9.490	-0.008	0.745	-0.007		

Sample size = 1322

Dependent Variable: PT, Excluded variable: China, People's Republic Of

Computed using α = 0.05

Table 4.8 - Build Location regression results for PT

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.327	0.322
ShipSize	0.084	0.169	< 0.001	0.140		
DelYear	18.656	2.353	< 0.001	0.180		
SupplySit	4.074	0.392	< 0.001	0.239		
DemSit	-10.523	-0.746	< 0.001	-0.457		
BuildLocation			< 0.001			
Brazil	-109.962	-0.056	0.027	-0.050		
India	293.256	0.100	< 0.001	0.096		
Netherlands	-224.529	-0.070	0.004	-0.066		
Norway	-455.290	-0.316	< 0.001	-0.246		
USA	-113.219	-0.087	0.002	-0.071		

Sample size = 1322

Dependent Variable: DT, Excluded variable: China, People's Republic Of

Computed using α = 0.05

Table 4.9 - Build Location regression results for DT

In the two tables above, there is one excluded variable from the categorical variable. This is the country of China, as it acts as a reference variable for the other countries in the BuildLocation variable. The B-values thus explain the difference in production or delivery time compared to the Chinese B-values that is not shown. The overall significance of the BuildLocation variable is also shown. This was computed using the General Linear Model in IBM SPSS Statistics, as mentioned in section 3.3.1. The overall Build Location variable was significant for both PT & DT. As we recall, the alternative hypotheses for Build Location ($H_{1\text{-}IA}$ and $H_{1\text{-}IB}$) were that the production and delivery time of a ship is related to the Build Location of a ship. The results of the General Linear Model analysis and the Multiple Regression Analyses support these hypotheses.

Assessing the results of the Build Location model showed some interesting results regarding the covariates. It seemed as the four covariates could explain a portion of the variance in production and delivery time themselves. To investigate this further, multiple regression analyses were run on all countries, with the covariates as independent variables. The results of these runs are presented in Table 4.10 and Table 4.11. The tables show the sample size, significance level of the covariates, the R^2 and the adjusted R^2 for each country.

Country	*N*	*ShipSize*	*DelYear*	*SupplySit*	*DemSit*	*R^2*	*Adjusted R^2*
Brazil	128	0.056	0.000	0.951	0.043	0.174	0.148
China	454	0.101	< 0.001	< 0.001	< 0.001	0.749	0.747
India	55	0.219	0.106	0.085	0.397	0.128	0.058
Netherlands	45	0.810	0.48	0.46	0.85	0.303	0.234
Norway	273	< 0.001	< 0.001	0.001	< 0.001	0.189	0.176
USA	367	< 0.001	< 0.001	0.979	< 0.001	0.315	0.308

Dependent Variable: PT

Computed using $\alpha = 0.05$

Table 4.10 – Covariates effect on production time in build location countries

Country	*N*	*ShipSize*	*DelYear*	*SupplySit*	*DemSit*	*R^2*	*Adjusted R^2*
Brazil	128	0.653	0.230	0.857	0.724	0.067	0.037
China	454	< 0.001	< 0.001	< 0.001	< 0.001	0.718	0.715
India	55	< 0.001	0.341	0.005	0.927	0.332	0.279
Netherlands	45	0.242	0.112	0.116	0.739	0.082	-0.009
Norway	273	0.010	0.004	0.188	0.560	0.052	0.038
USA	367	< 0.001	0.009	0.710	< 0.001	0.092	0.082

Dependent Variable: DT

Computed using $\alpha = 0.05$

Table 4.11 – Covariates effect on production time in build location countries

Proximity to cluster

Model A, for proximity to cluster's effect on production time is summarized as: $F(5, 448) = 267.938$, $p < 0.001$, with $R^2 = 0.749$ and adjusted $R^2 = 0.747$. The model was significant at the 0.001 level (p-value).

Model B, for proximity to cluster's effect on delivery time is summarized as: $F(5, 448) = 229.130$, $p < 0.001$, with $R^2 = 0.719$ and adjusted $R^2 = 0.716$. The model was significant at the 0.001 level (p-value).

The value of R^2 and adjusted R^2, means that the model can explain approximately 74% of the variance in PT and 71% of the variance in DT, respectively. Table 4.12 and Table 4.13 contains the regression output values of proximity to cluster on production and delivery time.

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model			< 0.001		0.749	0.747
ShipSize	0.034	0.046	0.081	0.041		
DelYear	78.581	0.488	< 0.001	0.428		
SupplySit	7.912	0.478	< 0.001	0.342		
DemSit	-13.008	-0.698	< 0.001	-0.509		
Cluster	35.863	0.024	0.326	0.023		

Sample size = 454

Dependent Variable: PT

Computed using $\alpha = 0.05$

Table 4.12 - Cluster regression results for production time

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model			< 0.001		0.719	0.716
ShipSize	0.082	0.107	< 0.001	0.095		
DelYear	67.272	0.400	< 0.001	0.351		
SupplySit	9.033	0.523	< 0.001	0.374		
DemSit	-14.698	-0.755	< 0.001	-0.551		
Cluster	-56.256	-0.037	0.164	-0.035		

Sample size = 454

Dependent Variable: DT

Computed using $\alpha = 0.05$

Table 4.13 - Cluster regression results for delivery time

As we recall, the alternative hypotheses for proximity to cluster ($H_{1\text{-}IIA}$ and $H_{1\text{-}IIB}$) were that the production and delivery time of a ship is related to the shipyard's proximity to a cluster. The results of the Multiple Regression Analyses do not support these hypotheses.

Hull Offshoring

Model A, computed on 273 Norwegian PSVs, for offshoring of hull production's effect on production time is summarized as: F (5, 267) = 12.586, $p < 0.001$, with $R^2 = 0.191$ and adjusted $R^2 = 0.176$. The model was significant at the 0.001 level (p-value).

Model B, computed on 273 Norwegian PSVs, for offshoring of hull production's effect on delivery time is summarized as: F (5, 267) = 3.442, $p < 0.001$, with $R^2 = 0.061$ and adjusted $R^2 = 0.043$. The model was significant at the 0.001 level (p-value).

The value of R^2 and adjusted R^2, means that the model can explain approximately 17.6% of the variance in PT and 4.3% of the variance in DT, respectively. Table 4.14 and Table 4.15 contains the regression output values of Hull Offshoring on Norwegian PSVs.

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.191	0.176
ShipSize	0.046	0.212	< 0.001	.188		
DelYear	8.271	0.255	0.006	0.153		
SupplySit	2.012	0.380	< 0.001	0.184		
DemSit	-2.992	-0.433	< 0.001	-0.209		
Offshored	30.053	0.053	0.396	0.047		

Sample size = 273, Country = Norway

Dependent Variable: PT

Computed using $\alpha = 0.05$

Table 4.14 - Hull Offshoring regression results for production time

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.061	0.043
ShipSize	0.053	0.184	0.006	0.163		
DelYear	-13.963	-0.324	0.001	-0.194		
SupplySit	1.197	0.170	0.166	0.082		
DemSit	0.682	0.074	0.548	0.036		
Offshored	79.085	0.105	0.121	0.092		

Sample size = 273, Country = Norway

Dependent Variable: DT

Computed using $\alpha = 0.05$

Table 4.15 - Hull Offshoring regression results for delivery time

Model A, computed on 45 Dutch PSVs, for offshoring of hull production's effect on production time is summarized as: F (5, 39) = 3.476, p < 0.001, with $R^2 = 0.308$ and adjusted $R^2 = 0.220$. The model was significant at the 0.001 level (p-value).

Model B, computed on 45 Dutch PSVs, for offshoring of hull production's effect on delivery time is summarized as: F (5, 39) = 3.442, p < 0.001, with $R^2 = 0.061$ and adjusted $R^2 = 0.043$. The model was significant at the 0.001 level (p-value).

Table 4.16 and Table 4.17 contains the regression output values of Hull Offshoring on Dutch PSVs.

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.308	0.220
ShipSize	0.022	0.109	0.754	0.042		
DelYear	9.920	0.557	0.177	0.183		
SupplySit	-4.039	-0.754	0.064	-0.254		
DemSit	4.373	0.659	0.078	0.241		
Offshored	-98.442	-0.151	0.605	-0.070		

Sample size = 45, Country = Netherlands

Dependent Variable: PT

Computed using $\alpha = 0.05$

Table 4.16 - Hull Offshoring regression results for production time on Dutch PSVs

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.083	-0.034
ShipSize	-0.041	-0.179	0.655	-0.069		
DelYear	11.388	0.565	0.233	0.186		
SupplySit	-4.199	-0.692	0.136	-0.234		
DemSit	1.214	0.162	0.702	0.059		
Offshored	-49.606	-0.067	0.841	-0.031		

Sample size = 45, Country = Netherlands

Dependent Variable: DT

Computed using $\alpha = 0.05$

Table 4.17 - Hull Offshoring regression results for production time on Dutch PSVs

As the correlations for the DemSit and DelYear variables seemed to indicate collinearity, both according to Pearson's correlation coefficients and the VIF-values, the analyses were run without these covariates for all iterations on Dutch PSVs. However, this did not improve the significance or the explanatory strength of any of analyses, and the outcome of the models were the same. Thus, the models with all covariates are used in the results presented in this chapter, to keep consistency in the results reporting.

As we recall, the alternative hypotheses for Hull Offshoring (H_{1-IIIA} and H_{1-IIIB}) were that the production and delivery time of a ship is related to the whether the shipyard offshores hull production or not. The results of the Multiple Regression Analyses do not support these hypotheses, as the "Offshored"-variable is not significant for any of the analyses models. Figure 4.3 below shows how the Norwegian shipbuilding industry started offshoring hull production of PSVs in 1999, and how they have practiced hull offshoring with most of their PSVs since. The Dutch shipbuilding industry started hull offshoring in 2012, as seen in Figure 4.4. Both figures contain a blue line, that occasionally overlap the orange line for total built ships. This happens when all the ships are built without hull offshoring.

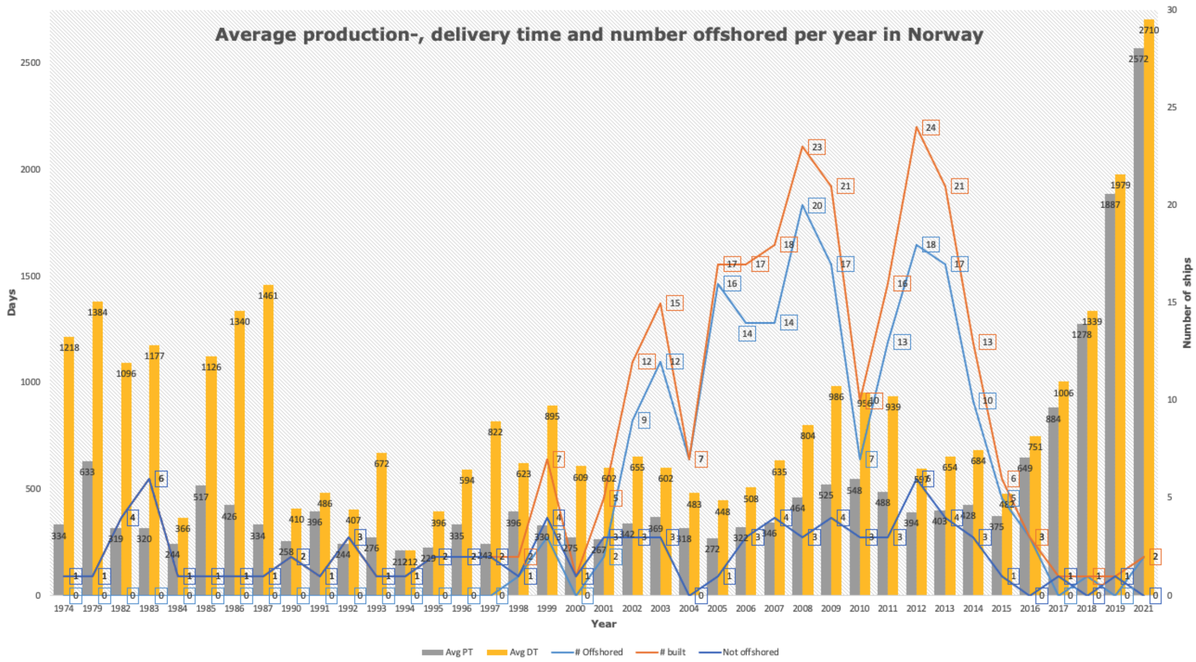

Figure 4.3 – Average PT & DT and number of offshored Norwegian PSVs

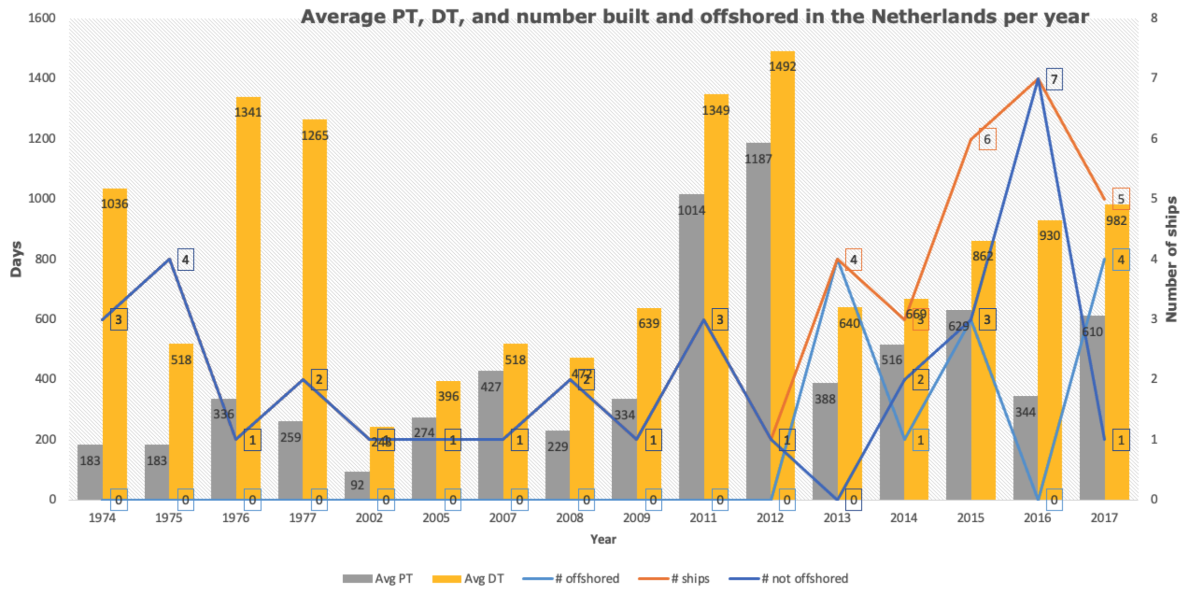

Figure 4.4 – Average PT & DT and number of offshored Dutch PSVs

Design Offshoring

Model A, for Offshoring of Design's effect on production time is summarized as: F (5, 251) = 280.017, $p < 0.001$, with $R^2 = 0.848$ and adjusted $R^2 = 0.845$. The model was significant at the 0.001 level (p-value).

Model B, for Offshoring of Design's effect on delivery time is summarized as: F (5, 251) = 178.830, $p < 0.001$, with $R^2 = 0.781$ and adjusted $R^2 = 0.776$. The model was significant at the 0.001 level (p-value).

The value of R^2 and adjusted R^2, means that the model can explain approximately 84% of the variance in PT and 77% of the variance in DT, respectively. Table 4.17 and Table 4.18 contains the regression output values of Design Offshoring.

Variable	***B***	***Beta***	***Sig.***	***Part***	***R^2***	***Adjusted R^2***
Model					0.848	0.845
ShipSize	0.017	0.022	0.444	0.019		
DelYear	104.150	0.617	< 0.001	0.487		
SupplySit	3.037	0.179	< 0.001	0.124		
DemSit	-11.886	-0.632	< 0.001	0.487		
OffDes	-3.094	-0.004	0.887	-0.003		

Sample size = 257

Dependent Variable: PT

Computed using $\alpha = 0.05$

Table 4.18 - Design Offshoring regression results for production time

Variable	***B***	***Beta***	***Sig.***	***Part***	***R^2***	***Adjusted R^2***
Model					0.781	0.776
ShipSize	0.091	0.114	0.001	0.097		
DelYear	95.157	0.060	< 0.001	0.424		
SupplySit	2.747	0.154	< 0.001	0.107		
DemSit	-11.997	-0.609	< 0.001	-0.469		
OffDes	50.394	0.060	0.067	0.054		

Sample size = 257

Dependent Variable: DT

Computed using $\alpha = 0.05$

Table 4.19 - Design Offshoring regression results for delivery time

As we recall, the alternative hypotheses for Design Offshoring ($H_{1\text{-}IVA}$ and $H_{1\text{-}IVB}$) were that the production and delivery time of a ship is related to the whether the shipyard offshores design capabilities or not. The results of the Multiple Regression Analyses do not support these hypotheses. None of the models show significant p-values for the OffDes variable. The different Design Offshoring strategies practiced at Chinese shipyards are presented in Figure 4.5.

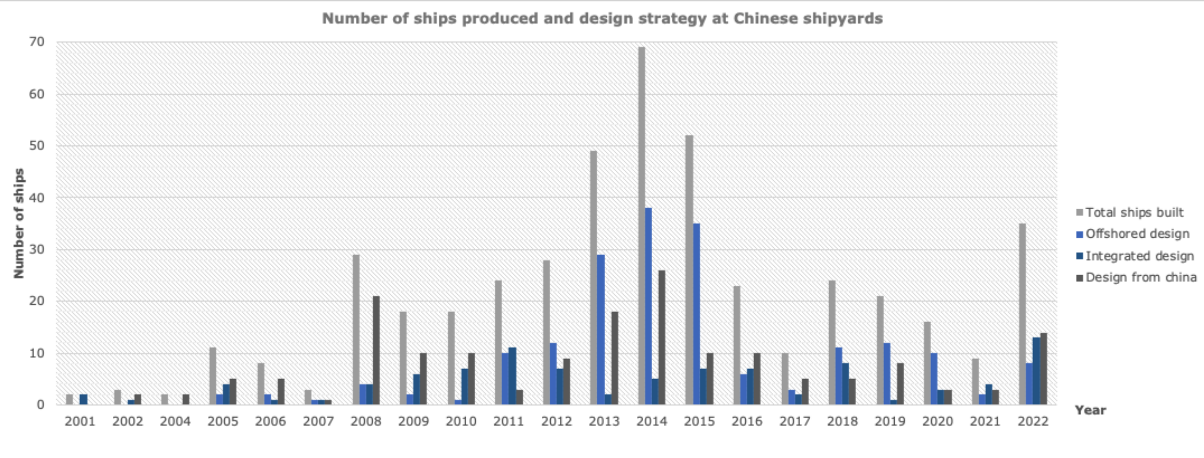

Figure 4.5 – Design Offshoring strategies at Chinese shipyards

Vertical Integration of Design

Model A, for vertical integration of design's effect on production time of Chinese PSVs is summarized as: F (5, 244) = 149.827, $p < 0.001$, with $R^2 = 0.754$ and adjusted R^2 = 0.749. The model was significant at the 0.001 level (p-value).

Model B, for vertical integration of design's effect on delivery time of Chinese PSVs is summarized as: F (5, 244) = 150.980, $p < 0.001$, with $R^2 = 0.756$ and adjusted R^2 = 0.751. The model was significant at the 0.001 level (p-value).

The value of R^2 and adjusted R^2, means that the model can explain approximately 75% of the variance in PT and 75% of the variance in DT, respectively. Table 4.20 and Table 4.21 contains the regression output values of Vertical Integration of design on Chinese PSVs.

Variable	***B***	***Beta***	***Sig.***	***Part***	***R^2***	***Adjusted R^2***
Model					0.754	0.749
ShipSize	.037	0.046	0.239	0.037		
DelYear	79.510	0.508	< 0.001	0.415		
SupplySit	8.173	0.516	< 0.001	0.326		
DemSit	-14.372	-0.743	< 0.001	-0.509		
Vertint	-289.346	-0.149	< 0.001	-0.128		

Sample size = 250

Dependent Variable: PT, Location = China

Computed using $\alpha = 0.05$

Table 4.20 – Vertical Integration of Design regression results for production time on Chinese PSVs

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.756	0.751
ShipSize	0.039	0.048	0.223	0.039		
DelYear	69.684	0.439	< 0.001	0.359		
SupplySit	9.412	0.586	< 0.001	0.370		
DemSit	-16.261	-0.828	< 0.001	-0.567		
VertInt	-277.725	-0.141	< 0.001	-0.121		

Sample size = 250

Dependent Variable: DT, Location = China

Computed using $\alpha = 0.05$

Table 4.21 – Vertical Integration of design regression results for delivery time on Chinese PSVs

The analyses that focused on Chinese shipyards, consisted of 140 ships built at shipyards with vertically integrated design capabilities. 207 out of the total of the 347 Chinese PSVs were constructed at shipyards outsourcing design to other Chinese companies. Of the Norwegian sample, 13 ships were constructed at shipyards with an integrated design, while the remaining 69 were constructed with outsourced design.

Model A, for vertical integration of design's effect on production time of Norwegian PSVs is summarized as: $F(5, 76) = 2.892$, $p < 0.001$, with $R^2 = 0.160$ and adjusted $R^2 = 0.105$. The model was significant at the 0.001 level (p-value).
Model B, for vertical integration of design's effect on delivery time of Norwegian PSVs is summarized as: $F(5, 76) = 5.973$, $p < 0.001$, with $R^2 = 0.282$ and adjusted $R^2 = 0.235$. The model was significant at the 0.001 level (p-value).

The value of R^2 and adjusted R^2, means that the model can explain approximately 75% of the variance in PT and 75% of the variance in DT, respectively. Table 4.22 and Table 4.23 contains the regression output values of Vertical Integration of design on Norwegian PSVs.

Variable	B	Beta	Sig.	Part	R^2	Adjusted R^2
Model					0.160	0.105
ShipSize	0.028	0.186	0.130	0.161		
DelYear	-0.231	-0.012	0.937	-0.008		
SupplySit	2.462	0.649	0.015	0.262		
DemSit	-2.145	-0.420	0.096	-0.177		
Vertint	-60.829	-0.107	0.319	-0.106		

Sample size = 82

Dependent Variable: PT, Location = Norway

Computed using $\alpha = 0.05$

Table 4.22 - Vertical Integration of design regression results for production time on Norwegian PSVs

Variable	*B*	*Beta*	*Sig.*	*Part*	*R^2*	*Adjusted R^2*
Model					0.282	0.235
ShipSize	0.049	0.186	0.103	0.160		
DelYear	-25.478	-0.787	< 0.001	-0.528		
SupplySit	3.001	0.455	0.063	0.183		
DemSit	0.498	0.056	0.808	0.024		
Vertint	-65.475	-0.066	0.504	-0.065		

Sample size = 82

Dependent Variable: DT, Location = Norway

Computed using α = 0.05

Table 4.23 - Vertical Integration of design regression results for delivery time on Norwegian PSVs

As we recall, the alternative hypotheses for Vertical Integration of Design ($H_{1\text{-}VA}$ and $H_{1\text{-}VB}$) were that the production and delivery time of a ship is related to the degree of vertical integration of design capabilities at the shipyard. The results of the Multiple Regression Analyses support these hypotheses on Chinese PSVs, as the VertInt variable is significant for both PT and DT. As presented in Table 4.22 and Table 4.23, the production and delivery time of PSVs decrease by approximately 289 and 278 days, respectively, if the design company is vertically integrated at the shipyard that produce the ship.

4.2.2 Assumption investigation

To ensure the robustness and quality of the results, we investigated and tested the underlying assumptions for multiple regression analysis.

Linearity of the Phenomenon

The linearity of associations between the dependent and independent variables was evaluated using scatterplots, which plotted the standardized predicted values of the dependent variable against the standardized residuals. A curve called the Loess Curve, which fits the data in a non-linear manner, is added to the graphs. This curve serves the dual purpose of identifying any non-linearity in the data and highlighting observable trends within the plots. Investigating the scatter plots inferred that the models adhere to the linearity assumption. The scatter plots are included in Appendix F for further reference. Additionally, partial regression plots were used to confirm if linear relationships were present between the dependent variables and each of the independent

Constant variance of the error terms (Homoscedasticity)

The principle of homoscedasticity implies that the variation is uniform across all values of the predicted dependent variable (Hair et al., 2014). To determine the presence of heteroscedasticity, the scatterplots generated to assess the linearity of the phenomenon were analyzed, specifically by investigating the graphs of the studentized residuals against the unstandardized predicted values. These scatterplots are available in appendix F. Additionally, Lavene's test for equality of error variance was applied to all models to check for any heteroscedasticity. While Lavene's test and examining the residual plots indicate the presence of heteroscedasticity across most of the models, heteroscedasticity is considered to be within acceptable standards to assess the results of the analyses.

Multivariate normality

The variables in a multiple regression model should be normally distributed. We recall how assessing whether the variables are normally distributed can be done by examining histograms or normal probability plots. The histograms of the models, for both dependent variables, are found in appendix F. The Normal P-P Plot of Regression Standardized Residuals are also found in appendix F. Both histograms and normal probability plots were examined to assess multivariate normality. The deviations from normality are considered to be within acceptable levels.

Independence of Error Terms

The indepenence of error terms were investigated by assessign the undstandardized residuals against the variable of delivery year. These scatterplots can be found in appedix F, under the scatterplots of the build location model. As the results of these graphs suggested a potential deviation from independance of error terms, the Durbin-Watson test was used. The Durbin-Watson test is used to check if consecutive observations (more specifically, their errors) are interrelated, implying they're not independent. The results of the Durbin-Watson tests are presented in Table 4.24. Investigating the values, Field (2013) suggest values less than 1 or greater than 3 is cause for concern. The values of the models in Table 4.24 suggest that there are not a obvious cause for consern, and the assumption of independence of error terms are considered satisfied to the degree where the analyses results can be interpreted.

Model	PT	DT
Build Location	1.449	1.591
Cluster	1.328	1.353
Hull Offshoring	1.921	1.924
Design Offshoring	1.651	1.423
VI of design	1.350	1.399

Table 4.24 - Durbin-Watson test values for analyses models

Absence of multicollinearity

To check if multicollinearity was present, meaning two or more independent variables were closely related, we examined both correlation coefficients and Variance Inflation Factor (VIF) values. We recall that when using VIF to analyze multicollinearity, one look for estimates of whether a variable has a strong relationship with the other variable(s). If the tolerance value (which is 1/VIF) drops below 0.1, it might indicate a problem with collinearity (Hair et al., 2014). The tolerance and VIF values for each model are detailed in

Table 4.25. Keep in mind that tolerance and VIF values remain constant within models, no matter the dependent variables. Hence, just one table is compiled for each analysis model. No values indicate any sign of multicollinearity, and the assumption for absence of multicollinearity can be considered met for all analysis models.

Model	Variable	Tol	VIF
Build Location	ShipSize	0.689	1.451
	DelYear	0.472	2.121
	SupplySit	0.362	2.761
	DemSit	0.375	2.668
	Brazil	0.814	1.229
	India	0.919	1.088
	Netherlands	0.885	1.130
	Norway	0.607	1.646
	USA	0.661	1.512
Cluster	ShipSize	0.629	1.590
	DelYear	0.644	1.552
	SupplySit	0.519	1.926
	DemSit	0.509	1.966
	Cluster	0.829	1.207
Hull Offshoring	ShipSize	0.788	1.268
	DelYear	0.359	2.784
	SupplySit	0.235	4.252
	DemSit	0.232	4.318
	Offshored	0.771	1.296
Design Offshoring	ShipSize	0.655	1.526
	DelYear	0.668	1.496
	SupplySit	0.469	2.133
	DemSit	0.398	2.512
	OffDes	0.739	1.353
VI of design	ShipSize	.655	1.526
	DelYear	.668	1.496
	SupplySit	.398	2.512
	DemSit	.469	2.133
	VertInt	.739	1.353

Table 4.25 - Tolerance and VIF-values

The assumptions of multiple regression were also investigated for the Hull Offshoring model on Dutch PSVs, and the VI of Design model on Norwegian PSVs, even though these are not specifically shown in section 4.2.2 and the appendix. This was to ensure a transparent and clear assumption investigation and coherent appendix. The investigation for these models did not indicate any violations of the assumptions for multiple regression.

Although it is deemed unlikely that these deviations had any significant impacts on this study's main findings and implications, any deviations from the assumptions must be kept in mind when interpreting the regression results.

4.3 Hypoteses testing

This section examines and assesses the null and alternative hypotheses as outlined in Chapter 3.3.6. The null hypothesis suggests a non-existent relationship between a specified set of dependent and independent variables. Conversely, the alternative hypothesis presumes a significant connection. When the association between the dependent and independent variable is noteworthy at a 0.05 level ($p < 0.05$), we acknowledge the support for the alternative hypothesis in consideration. However, if the p-value exceeds the 0.05 threshold ($p > 0.05$), the relationship is deemed insignificant, and the alternative hypothesis is therefore not supported. The results of the alternative hypotheses testing are summarized in Table 4.26.

Hypothesis	Independent variable	Dependent variable	Result
$H_{1\text{-}IA}$	Build location	PT	Supported (p < .001, N = 1322)
$H_{1\text{-}IB}$	Build location	DT	Supported (p < 0.001, N = 1322)
$H_{1\text{-}IIA}$	Cluster	PT	Rejected (p = 0.326, N = 454)
$H_{1\text{-}IIB}$	Cluster	DT	Rejected (p = 0.164, N = 454)
$H_{1\text{-}IIIA}$	Offshored	PT	Rejected for Norway (p = 0.396, N = 273) Rejected for Netherlands (p = 0.605, N = 45)
$H_{1\text{-}IIIB}$	Offshored	DT	Rejected for Norway (p = 0.121, N = 273) Rejected for Netherlands (p = 0.841, N = 45)
$H_{1\text{-}IVA}$	DesOff	PT	Rejected (p = 0.887, N = 257)
$H_{1\text{-}IVB}$	DesOff	DT	Rejected (p = 0.067, N = 257)
$H_{1\text{-}VA}$	VertInt	PT	Supported for China (p < .001, N = 250) Rejected for Norway (p < 0.319, N = 82)
$H_{1\text{-}VB}$	VertInt	DT	Supported for China (p < .001, N = 250) Rejected for Norway (p < 0.504, N = 82)
$H_{1\text{-}VIA}$	ShipSize	PT	Supported for Build Location, Hull Offshoring (p < .001, N = various) Rejected for Proximity to Cluster, Design Offshoring and Vertical Integration of Design (p >= 0.081, N = various)
$H_{1\text{-}VIB}$	ShipSize	DT	Supported for Build Location, Proximity to Cluster, Hull Offshoring and Design Offshoring (p < .006, N = various) Rejected for Vertical Integration of Design (p = 0.223, N =250)
$H_{1\text{-}VIIA}$	DelYear	PT	Supported for all models (p < 0.006, N = various
$H_{1\text{-}VIIB}$	DelYear	DT	Supported for all models (p < 0.001, N = various)
$H_{1\text{-}VIIIA}$	SupplySit	PT	Supported for all models (p < 0.001, N = various)
$H_{1\text{-}VIIIB}$	SupplySit	DT	Rejected for Hull Offshoring (p = 0.166, N = 273) Supported for all other models (p < 0.001, N = various)
$H_{1\text{-}IXA}$	DemSit	PT	Supported for all models (p < 0.001, N = various)
$H_{1\text{-}IXB}$	DemSit	DT	Rejected for Hull Offshoring (p = 0.548, N = 273) Supported for all other models (p < 0.001, N = various)

Table 4.26 - Hypothesis testing results

5 Discussion

This chapter will analyze the multiple regression analyses and try to explain the obtained results. First, the results of how build location affect production and delivery times are presented and examined. Then, the results of the effects of factors related to build location on production and delivery times of PSVs are investigated. Ultimately, findings regarding the covariates effect on the PSV shipbuilding nations and practical implications of the results are discussed.

5.1 Production and delivery times are dependent on the build location

The results of the multiple regression analysis suggest that the alternative hypotheses $H_{1\text{-}IA}$ and $H_{1\text{-}IB}$ can be supported. The production and delivery times of PSVs are dependent on the build location of the shipbuilder. When accounting for variables such as the ship's size, delivery year, supply-, and demand situation, it becomes apparent that some nations' shipyards outpace others. Figure 5.1 and Figure 5.2 illustrate this relationship and show the partial residuals of the average production and delivery times of each build location, adjusted for the covariates.

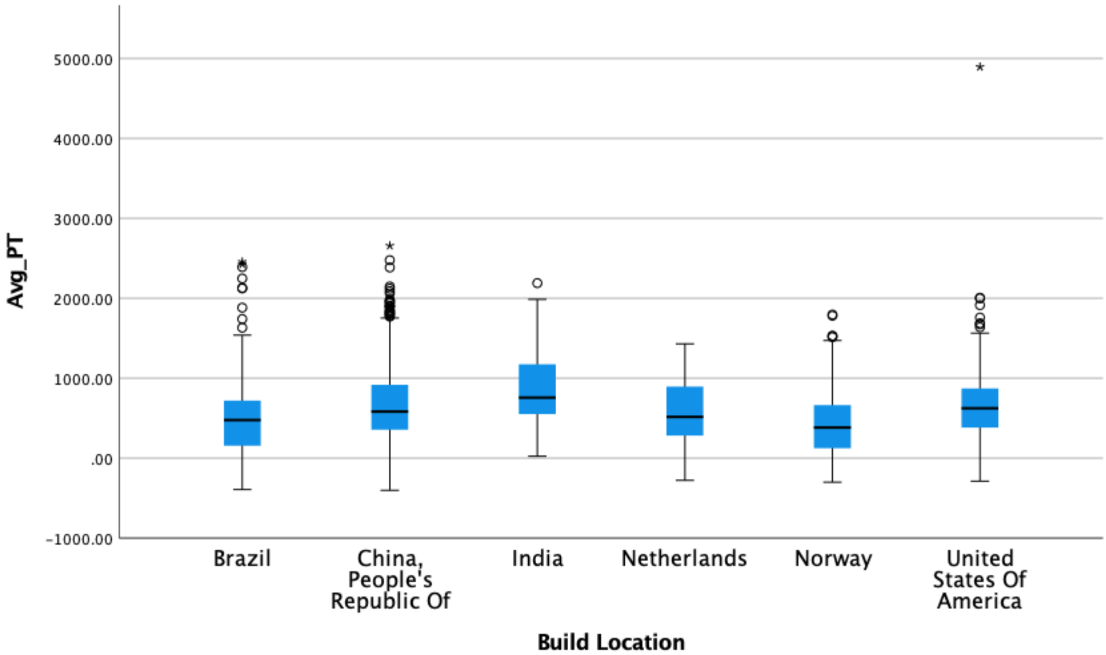

Figure 5.1 - Boxplot of partial residuals of average PT per build location

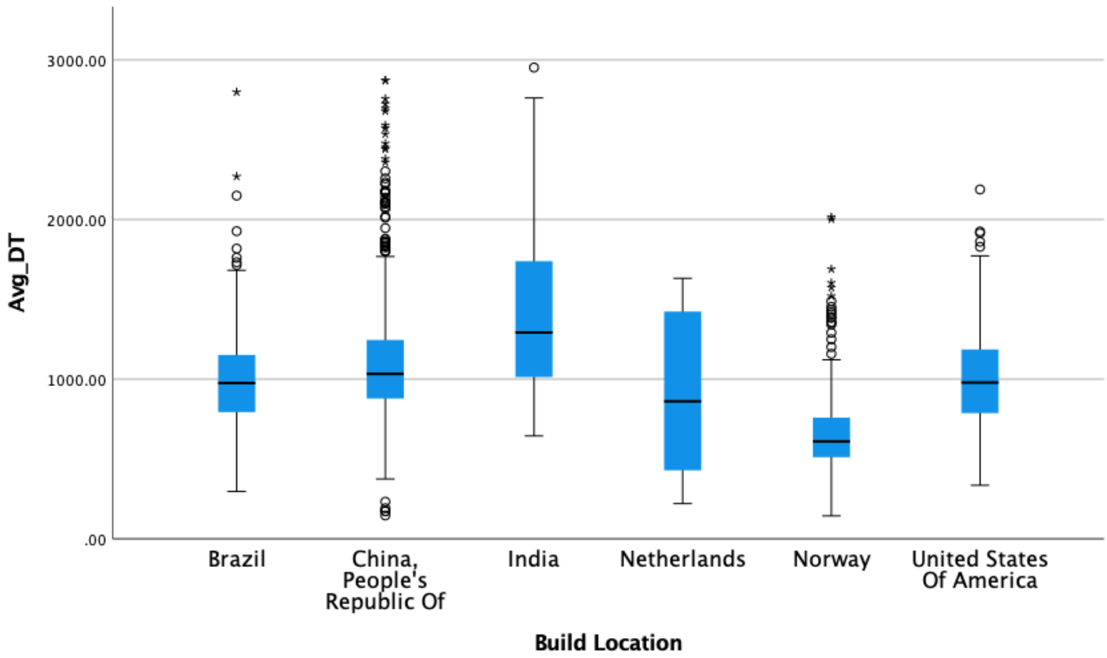

Figure 5.2 - Boxplot of partial residuals of average DT per build location

On average, PSVs built in India were produced 210 days more slowly and delivered 293 days later than Chinese PSVs. This might be attributed to the relative lack of advanced shipbuilding technology, less efficient production methods and low labor productivity, potentially leading to lengthier processes (Thangam and Sureshkumar, 2015). Despite their abundant labor force, they might face similar issues to those of the Chinese industry. The skill levels of workers and issues with quality control could perhaps influence the shipbuilding times, as well as the fact that the Chinese and Indian shipbuilding industries are used to producing larger ships in larger quantities, such as bulkers and tankers (Tsai, 2011, Thangam and Sureshkumar, 2015). The PSVs that were built in Brazil were on average produced and delivered 110 days faster than PSVs built in China. Still, Brazilian shipbuilders produced ships approximately 4.5 months slower and delivered them on average 11.5 months later than Norwegian shipyards. Delays in the Brazilian shipbuilding industry, as suggested by Ferreira (2015), could stem from difficulties related to changes in design and delays in equipment supplies.

American-built PSVs present an interesting case due to the influence of the Jones Act of 1920. The Jones Act assures that domestic ships are constructed at American shipyards, which is believed to have inflated contract prices and reduced shipbuilding productivity, compromising competitiveness (Frankel, 1996, Hossain and Zakaria, 2017). The regression results show how USA deliver PSVs on average almost 4 months later than Dutch shipyards, and almost a year later than Norwegian shipyards. The USA has been one of the world's biggest providers of offshore oil and gas, where PSVs are essential support vessels (EIA, 2016). This coincides with publicly available data, which shows how USA has a rich shipbuilding history, providing 367 PSVs over 1000 GT since 1975. As Norwegian yards started producing PSVs only one year before, delivering 273 PSVs since 1974, these results are not likely due to the experience of American yards when it comes to producing and delivering PSVs. The results of build location on production and delivery time consequently seem to substantiate the beliefs that the Jones Act has reduced shipbuilding productivity in the United States, at least in terms of production and delivery times.

Norwegian shipyards stand out with significantly faster production and delivery times, producing PSVs on average over 8 months faster and delivering them on average over a year quicker than those delivered from Chinese yards. These findings may not be surprising to most experts, as the Norwegian shipbuilding industry is known for its productivity and skilled workforce (OECD, 2017). The Chinese workforce, albeit a less skilled workforce than that of the Norwegian shipbuilding industry, is larger and cheaper (Varela et al., 2017). This could be expected to boost output, as they could use significantly more manpower per ship (Tsai, 2011, OECD, 2021). However, this could also introduce inefficiencies due to the potential for quality-related issues and the need for more supervision and training, which might extend the production and delivery time. The latter seems to be the most likely for production of PSVs, as the results of build location on production and delivery time clearly demonstrate how Norwegian shipyards drastically outperform the Chinese. Registered shipbuilding times of the Chinese and Indian shipyards compared to Norwegian yards could perhaps indicate that using a lot of manpower does not necessarily result in quicker production and delivery times of PSVs.

As mentioned, Norwegian shipyards have a long shipbuilding history, and have in recent decades especially focused on ships within specialized market segments. Norwegian shipbuilders deliver PSVs on average 230 days faster than Dutch shipbuilders. The Dutch and Norwegian shipbuilding industries are somewhat similar as they are Northern European countries focusing on similar ship market segments. The reason for the difference in PSV shipbuilding times between Dutch and Norwegian shipyards is unclear, but it could perhaps be tied to the fact that Norwegian shipyards has produced 273 PSV to the 45 Dutch PSVs. The Dutch shipyards also started producing PSVs in 1974, although had a large stop in production from 1977 to 2002 and has only produced 45 PSVs in total. The Netherlands and Norway are known for offshoring hull production to other European countries such as Poland, Romania, Ukraine, and Turkey (OECD, 2017, OECD, 2020). However, this phenomenon has been analyzed and will be further discussed later in this chapter.

5.2 Factors related to build location that could explain some of the variance in PSV shipbuilding times

This section investigates how the factors related to the build location of a ship affect the production and delivery time of PSVs and assess the results of the analyses conducted in Chapter 4. First, the results and effects of vertical integration of design capabilities on production and delivery time of Chinese and Norwegian PSVs are discussed. Thereafter, the other analyses' results are discussed as the aim is to investigate whether proximity to cluster, hull offshoring or design offshoring influence production and delivery times of PSVs. Lastly, the effects of each covariate are investigated.

Vertical Integration of design capabilities seem to reduce PSV shipbuilding times in China

The impact of vertical integration of design capabilities on the production and delivery times of PSVs was explored through a multiple regression analysis of both Norwegian and Chinese ships. The results show a significant relationship between vertical integration of design and production and delivery time on the Chinese sample, thereby supporting the alternate hypotheses $H_{1\text{-}VA}$ and $H_{1\text{-}VB}$. However, the alternative hypotheses must be rejected on the Norwegian sample where the relationship were non-significant.

Results of the multiple regression analyses found how the production and delivery time of Chinese PSVs was significantly longer when design was not vertically integrated at the shipyard. When design capabilities were a part of the shipyard's in-house capabilities, the production time decreased by an average of 289 days, while the delivery time decreased by an average of 277 days. These results align with the findings of Lamb and Hellesoy (2002), which discover how shipyards with greater vertical integration seem to be more productive. These findings could be attributed to the added complications from communication and coordination that may arise between separate companies, especially considering the complexity of ship design.

In contrast, Norwegian shipyards did not exhibit any influence of vertical integration of design capabilities on PSV shipbuilding times. Norwegian shipyards are known for close collaboration with design companies and exploitation of cluster synergies, which might mitigate the possible issues of collaboration between shipyards and external design firms (OECD, 2017). Moreover, Norwegian and other European shipyards are accustomed to collaborating with different companies, often offshoring hull production and providing design services for shipyards in various global regions. The domestic collaborative experience might be lacking in Chinese shipyards, which could impact their PSV production and delivery times. Further investigation into the collaboration dynamics between Chinese shipyards and design companies could reveal inefficiencies that might prolong production and delivery times when design and production capabilities are at separate locations.

Interestingly, the increase in delivery time is slightly shorter than the increase in production time. This indicates that the time lost between the keel laying and delivery is where the Chinese shipbuilders with outsourced design loose the most time on vertically integrated yards. If the communication and knowledge transfer between the companies are at its peak during this period, this could possibly explain some of this lost time. Haartveit et al. (2012) explain how project changes requires close collaboration, and so if the functions cooperating have little to no experience with this collaboration process it might extend thee production and delivery time. This is in line with thee argumentation of Moyst and Das (2005), which argue that integrating design and production can facilitate better communication, coordination and decision-making. Perhaps an explanation to the prolonged production and delivery times is that most Chinese shipyards and design companies are operating with what Haartveit et al. (2012) call a Market Yard approach, which infers no long-term relationships with knowledge sharing on a project-to-project basis. While these results underline the benefits of vertical integration of design, they must be interpreted with some caution. Other unaccounted factors such as specific competencies of the design firms, or the data collection process described in section 3.3.4 could potentially influence these results.

Proximity to clusters, hull offshoring, and design offshoring do not seem to implicate a change in PSV shipbuilding times

Proximity to cluster

The research failed to identify a significant association between proximity to a cluster and the production and delivery time of Platform Supply Vessels (PSVs), leading to the rejection of the alternative hypotheses $H_{1\text{-}IIA}$ and $H_{1\text{-}IIB}$. These results suggest that, based on solely this study, the variance in production and delivery times of PSVs built in China cannot be explained by the shipyard's proximity to a cluster. The findings of the analyses are surprising, as Porter (1998) suggests that shipyards located in a cluster can lead to improvements. However, Porter (1998) mainly emphasize improvements such as technological advancements, innovative solutions and close collaboration with suppliers and R&D. These are improvements that might, but not necessarily, lead to production and delivery time deduction. The spill-over effects of these improvements may primarily impact other performance indicators, such as cost-efficiency, rather than directly resulting in reduced production and delivery times.

One potential limitation of this study may lie in the data collection method, as described in section 3.3.4. The operationalization of the cluster variable was based on empirical observations and might not accurately represent the actual situation of Chinese shipyards. This could be due to the author's lack of prior experience in gathering data on Chinese shipbuilders and their associated clusters. Future research could focus on a more detailed examination of the impact of clusters, possibly employing surveys as a data collection method and expanding the geographical focus to include shipbuilders from various other global regions.

Hull Offshoring

The results do not provide support for the alternative hypotheses $H_{1\text{-}IIIA}$ or $H_{1\text{-}IIIB}$, for either the Norwegian or Dutch PSV sample. This implies that the variance in production and delivery times of PSVs delivered from Norwegian or Dutch yards could not be accounted for by the offshoring of hull production. It was speculated that the correlation of the covariates DemSit and DelYear with the offshoring variable could provide incorrect results. However, when these covariates were removed from the analysis models, the significance and overall explanatory power remained unaltered, suggesting these factors were not significantly influencing the results.

The findings are somewhat surprising, as previous literature have shown how offshored ships are influenced by the degree of hull offshoring and strategies related to it. Both Semini et al. (2022) and Semini et al. (2023) use similar data analyses, on other data samples, to prove how offshoring influence production and delivery time of specialized ships. As the mentioned papers focus on other data samples, featuring different ship types and/or ships produced in other countries, this could be an explanation to why the results are different. Semini et al. (2022) performed multiple regression analysis on OSVs delivered from Norwegian yards, which can be considered to be a similar sample. They found that OSVs can be produced months faster when the hull is erected at a domestic shipyard compared to an offshoring yard.

Nevertheless, Semini et al. (2023) argue that other factors within the industrial environment of a shipyard is more likely to explain the differences in production and delivery times between shipyards than hull offshoring. This is in line with the findings of this study, where the analyses results do not find that hull offshoring can explain the variance in PSV shipbuilding times. Still, the fact that there is no significant relationship between hull offshoring and production and delivery time of PSVs are interesting, as it suggest that hull offshoring does not provide disadvantages in time performance.

Offshoring yards often have a lot of experience and a high level of specialization in hull production, which can potentially match or exceed the capabilities of domestic yards. If these offshore shipyards are hypothetically more efficient, utilize benefits of scale and automation, the impact of for instance the geographical distance or the hull transport time could be mitigated. Other aspects such as high-quality project management practices and a well-integrated supply chain, can ensure efficiency and the successful movement of the hull from the offshore location to the final assembly location, which can potentially explain how the effect of hull offshoring does not prolong shipbuilding times. Another aspect that might be relevant, is the fact that Norwegian and Dutch yards are used to collaborating and offshoring hull production, which could lead to the production and delivery times of hull offshoring to be indifferent from hull construction at domestic yards. If these results and arguments are at all accurate, Norwegian and Dutch shipbuilders can continue to reap the benefits of hull offshoring, whilst not sacrificing competitiveness in terms of slower production and delivery times.

Design Offshoring

A significant relationship between offshoring of design and the production and delivery time of PSVs was not identified, so the alternative hypotheses $H_{1\text{-}IVA}$ and $H_{1\text{-}IVB}$ were rejected. These findings are interesting, as they indicate that the offshoring of design capabilities cannot explain the differences in PSV shipbuilding times at Chinese shipyards.

Several factors might influence these results. The complexity of ship design may present a challenge when offshored, particularly if the offshore design company and the shipyard are market yards that perhaps need to be better integrated (Haartveit et al., 2012). Communication, language, cultural differences, and coordination issues could slow down the design process and, subsequently, the production and delivery times of the vessels. This could be related to the assessments of Garcia Agis et al. (2020), who argues that one shoud improve the communication with vessel owners and other stakeholders in order to improve effectiveness in design processess.

Conversely, the positive nature of the relationship between the shipyards and offshore design companies could play a role. A long-term, collaborative relationship such as what Haartveit et al. (2012) call Partner Yard, might mitigate potential issues related to offshoring design. Factors such as trust, mutual understanding, and collaborative experience could foster a more efficient design process, regardless of geographical distance. This might mitigate the negative effects of offshoring design of a ship and might be an explanation to why offshoring the design process does not lead to longer production and delivery times of PSVs.

If the findings of this study are correct, it might mean that Chinese yards can continue offshoring their designs to other countries without having to compromise on production and delivery times. This way, they can still exploit the quality and reputation that the use of foreign shipyards or design companies bring with their designs.

For offshoring design, it is important to note how the data collection process described in section 3.3.2, might affect the results of the analyses. Due to the authors lack of previous knowledge on Chinese shipbuilders and design companies, the results should be interpreted with this in mind. Further research should be done where the investigation of design offshoring is not empirical, subjective data collection. This could perhaps be done through a survey that can get assured and traceable data, or by utilizing an expert with insights and knowledge about the design capabilities and companies related to the Chinese shipbuilding industry.

The role of external factors and their influence on PSV shipbuilding times

To investigate the production and delivery time of PSVs across different build locations, the literature show how four external factors should be taken into consideration. These factors are now assessed individually and later discussed in unison to understand how and why they affect the regression results.

Ship Size

The covariate ship size (ShipSize) affects the production and delivery times of PSVs. The alternative hypotheses $H_{1\text{-}VIA}$ and $H_{1\text{-}VIB}$ are supported for most models. The values used in this chapter are taken from the build location model. As the size of the ship increase, so does the production and delivery time. The average production and delivery time is increased by 39 days (PT) and 84 days (DT) if the ship size increase in size by 1000 GT. By adjusting for ship size, the shipbuilding time variations between countries are not a direct effect of the dissimilarities in ship sizes between them. While the significance of the ship size variable varies in other analyses models, when significant, the results align with those obtained in the build location model.

Semini et al. (2022) find that the ships size, also measured in GT, affects the ships production time by prolonging it with 13 days, if a ship's size is increased by 1000 GT. The lower impact found in that study may be due to the types of ships analyzed. Compared to the PSVs investigated in this study, all the other ship types (AHTs, SOVs, etc.) included in Semini et al. (2022) are relatively larger. As the relationship between ship size and production and delivery time is logarithmic, this could explain the increase in effect that is found in this study, compared to the effect found in Semini et al. (2022). Semini et al. (2023) also investigate and find results that substantiate the effects of ship size on shipbuilding production and delivery times, with the natural logarithmic transformation of GT as the operationalized variable. However, assessing Pearson's correlations in Appendix D, reveals how the covariates are correlated with each other. For some models, their correlations are more prominent than others. Still, the correlations mean that one should be careful reading too much into the regression coefficients of these variables. Despite potential internal correlations, control variables are essential as their collective effect maintains the overall accuracy and interpretability of the models.

It was also considered measuring the size of the ship in CGT, to capture some of the complexity that an increased ship size might add. However, this did not increase the explanatory strength of the variable or the analyses models and was disregarded. The CGT transformation model of OECD (2007) does not consider different offshore vessel types, which perhaps can explain why it did not increase the explanatory strength. Complexity is however still an important aspect to consider and might explain some of the variance that the analyses models can't explain. Ebrahimi et al. (2021a) claim that complexity can explain a lot of the variance in ship design competitiveness. Given the importance of ship design in specialized shipbuilding, it's plausible to believe that complexity could affect production and delivery times of PSVs. Semini et al. (2022) speculate if perhaps the measurement of CGT does not capture the complexity of OSVs, an argument that can be transferred to this study, as the sample are PSVs and using CGT did not increase the explanatory strength. However, further research on the effect of complexity on PSV shipbuilding times is needed to be able to conclude on this hypothesis.

The effect of ship size on production and delivery time could have a natural explanation. Larger ships imply more work in terms of steel work, material flow, and outfitting, thereby extending the production and delivery times. Therefore, this study, in agreement with Semini et al. (2022) and Semini et al. (2023) confirms the importance of adjusting for ship size when investigating production and delivery time as a shipbuilding performance measurement.

Delivery Year

The covariate delivery year (DelYear) is important as it makes sure the time-performance variations between locations are not just an effect of how technological progress, changes in specifications or general improvements and changes over the years impacts shipbuilding times of PSVs. The analyses models seem to indicate a significant relationship between the year a ship is delivered and the production and delivery time of the ship, which provides support for the alternative hypotheses $H_{1\text{-}VIIA}$ and $H_{1\text{-}VIIB}$. Delivery year appears to have a clear effect on shipbuilding times of PSVs, presenting an average increase of on average one month in production time and almost three weeks in delivery time. This trend may reflect a range of factors, from technological advances that facilitate more complex builds, to increased regulatory measures and quality assurance measures that may lengthen timelines. As seen in Figure 4.3 and Figure 5.3, the recent years have seen an increase in production and delivery times in both in the Norwegian and Chinese PSV market segment. This could have likely been caused by external factors related to the market, such as the oil price drop of 2014 (Jakobsen et al., 2019). It appears the production and delivery times of the recent years have gotten so long that the market variables of supply- and demand situation cannot capture it themselves. Thus, it might be that the covariate of delivery year captures this effect, which could explain its extreme regression coefficients. Nevertheless, as mentioned in the ship size discussion it is acknowledged that the correlations between covariates renders their individual regression coefficients unreliable.

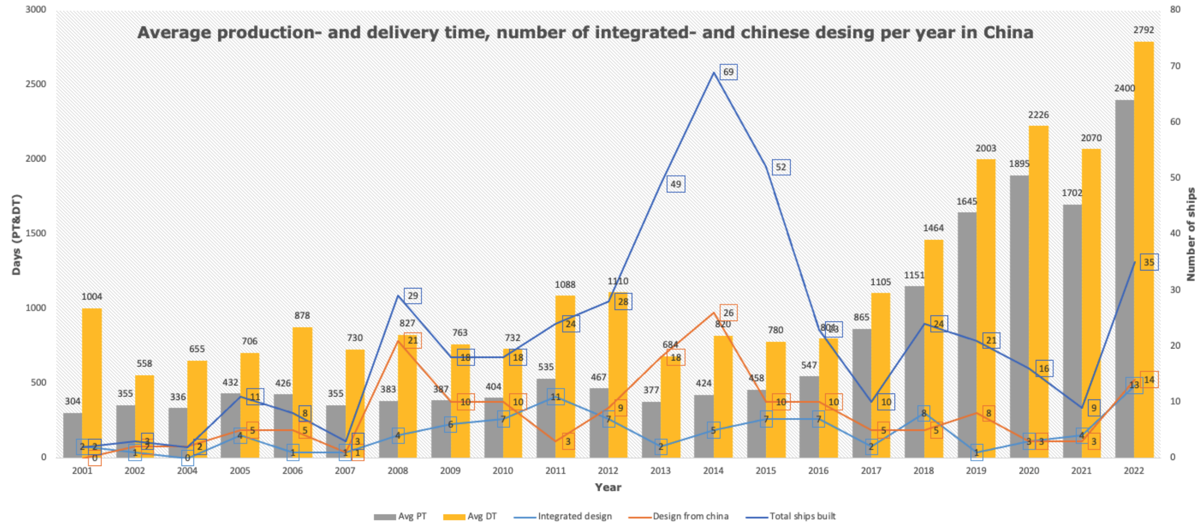

Figure 5.3 – Ships built per year and average PSV shipbuilding times at Chinese yards

Supply Situation

The analyses models reveal a significant relationship between the supply situation and the production and delivery times of PSVs, which provides support for the alternative hypotheses $H_{1\text{-}VIIIA}$ and $H_{1\text{-}VIIIB}$. Adjusting for the supply situation in the PSV market assures the variety in production and delivery times between build locations are not affected by the market segment intensity leading to fluctuations in for example capacity or delays from suppliers. The results of Semini et al. (2022) are in line with this study. There are several potential reasons as to why the supply situation could influence production and delivery times. When market supply is high, the demand for resources such as materials and labor also increase. This demand could lead to delays if suppliers struggle to meet the needs of all shipbuilders simultaneously. Furthermore, a high supply situation might also mean increased pressure on the production facilities, leading to potential capacity issues or constraints, which in turn can extend production and delivery times. As Semini et al. (2022) point out, the findings are consistent with the research of Durdyev and Hosseini (2020) on causes of delays in the construction industry.

Demand Situation

Demand situation (DemSit) is important as it makes sure the time-performance variations are not just a direct effect of the market demand being better or worse between countries. The analyses models seem to indicate a significant relationship between the demand situation in the market and the production and delivery times of PSVs, which provides support for the alternative hypotheses $H_{1\text{-}IXA}$ and $H_{1\text{-}IXB}$. The findings of this study align with the reasoning made in Semini et al. (2022), as the production and delivery time of PSVs decrease with approximately 9-10 days as the demand situation in the PSV market segment increase. Still, it is reminded that the regression coefficients of the covariates are unreliable. The market situation variables, namely supply situation and demand situation, and the delivery year variable, are computed from the data showed in Figure 5.4. The graph can possibly give some explanation to the correlations between these variables and delivery year, as the market fluctuates between different delivery years.

Semini et al. (2022) found that the demand situation decreases shipbuilding times of OSVs. There are several reasons why demand situation might affect production and delivery times. An increase in demand could lead to a higher priority for production resources, potentially accelerating production and delivery times. Alternatively, higher demand could stimulate efficiency improvements and innovation within production processes to meet this increased need, resulting in faster build times.

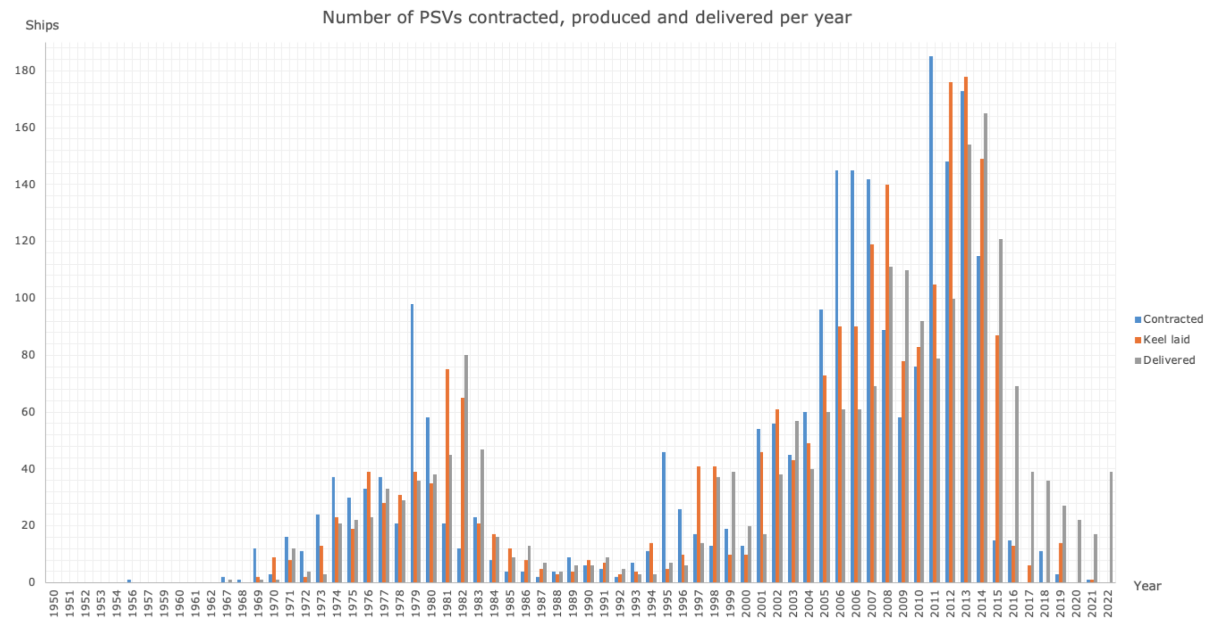

Figure 5.4 - Number of PSVs contracted, built (keel laid) and delivered per year

As presented in Table 4.10 and Table 4.11, the covariates can explain a lot of the variance in production and delivery times in some of the countries. This is interesting, as it indicates that for instance in China, the variance in production and delivery times are strongly tied to external factors. Notably, market situation-related factors such as delivery year, supply situation and demand situation are highly correlated with production and delivery time of Chinese PSVs. Conversely, these covariates do not seem to be able to explain a lot of the variance in production and delivery times in the Norwegian PSV market. This might suggest that Norwegian PSV shipbuilders are less vulnerable to external market-related factors than their Chinese counterparts. This is highly interesting, as this could be tied to the Norwegian shipbuilders' ability to effectively manage market fluctuations, potentially through strategic measures like employing a flexible workforce. Norwegian shipyards employ a varying number of contract workers from year to year reliant on their orderbooks, with contract workers reaching the values of almost 50% of total employees (OECD, 2017). The Chinese shipbuilding industry, with its large scale and generally high level of integration, may be more sensitive to market dynamics, including changes in demand and supply. Norwegian shipyards, on the other hand, might be more resilient due to their experience and adaptation strategies, allowing them to weather market fluctuations more efficiently. It is possible that market dynamics exert a more significant influence than what we are currently able to quantify with the chosen market variables. It is recognized that the market might play a larger role than what is visible through this study's research.

Brief discussion of methods

As mentioned in section 3.3.2, the presence of outliers might distort the regression results by making the model fit to these exceptional observations rather than the underlying trend of the bulk of the data. Most of the analyses, except perhaps the investigation of the covariates effect on Dutch PSVs, consist of large data samples. Although larger sample sizes are typically beneficial due to their ability to enhance the statistical power of the analysis, they can also lead to the detection of statistically significant results for even minor effect sizes or relationships. Also, the multiple regression analysis relies on several key assumptions. Any substantial deviation from these can result in biased or inconsistent estimates, potentially leading to misinterpretation of the results. The graph of unstandardized residuals on delivery year, for both production and delivery times are presented in appendix F. These graphs suggests that there might not be independence of error terms. The graphs show trends that could perhaps indicate a learning effect at the start, and the effect of market factors that the covariates could not pick up towards the end of the graphs. Even though the Durbin-Watson values presented in Table 4.24 provided the basis to continue with the results interpretations, the possible deviations from assumptions should be kept in mind. It is critical to remember these points potential influence on the results, as it is a potential limitation of the study.

5.3 Practical implications

Chapter 5 has discussed the results of the multiple regression analyses. Through this discussion some practical implications can be formulated, which are now presented.

First, results were discussed on how the build location of a PSV seems to influence its production and delivery times. Some countries outpace others, especially the Norwegian shipbuilding industry. Accordingly, as Norwegian yards are focused on highly innovative vessels with innovative features and produce and deliver ships much faster than other countries, these findings could be a potential competitiveness argument for the Norwegian shipbuilders when trying to persuade shipowners to build their new ships at their shipyards.

Then, several build locations were investigated to see if some of the difference in shipbuilding times could be attributed to the found factors related to build location. Results implicate that Chinese shipyards should vertically integrate design capabilities to be more competitive regarding production and delivery times of PSVs. The results also seem to confirm that hull offshoring does not seem to affect production and delivery times of PSVs, thus substantiating the notion that other factors are of more importance. This indicates that Norwegian shipyards and other high-cost countries can continue offshoring hull production to lower costs and build their competitiveness around other core capabilities.

Discussion of the results regarding the covariates seem to suggest that factors within the market-aspect are important in certain shipbuilding industries, such as China. Although this study seems to confirm the importance of adjusting for ship size, factors related to the market situation seem likely to be prominent in explaining variations in PSV shipbuilding times in the Chinese industry. Understanding and predicting market fluctuations and trends might be of future importance to certain shipyards located in China, in addition to focusing on production-specific factors to reduce production and delivery times.

6 Conclusions

This chapter presents the practical implications of the research, highlights the limitations of the study, and offers suggestions for future research.

6.1 Research findings

The aim of this theses has been to answer the research questions presented in Chapter 1, which sought to explore: (1) the dependance of Build Location on production and delivery time of PSVs, (2) the influence of proximity to clusters, offshoring of hull production, and offshoring of design on the production and delivery time of PSVs, and (3) the impact of vertical integration of design capabilities on the production and delivery time of PSVs.

The investigation of literature and results of multiple regression analyses demonstrate the significant impact of Build Location on the production and delivery times of PSVs. However, findings of this study do not provide grounds to conclude that proximity to cluster, offshoring of hull production, and offshoring of design have any noticeable effect on the production and delivery times of PSVs. Further assessing the results, it seems reasonable to conclude that within the Chinese shipbuilding context, vertical integration of design capabilities appears to substantially reduce production and delivery times of PSVs. This reinforces the idea that effective communication, collaboration, and coordination, especially in the design phase, can possibly reduce production and delivery times. Furthermore, this study provides information on how utilizing a cheaper workforce and using more manpower per ship does not necessarily help reduce shipbuilding times, as Chinese and Indian shipyards have a substantial gap in time performance compared to Norwegian yards.

These findings emphasize the complex nature of global shipbuilding and the need for individual shipbuilders to strategically leverage their unique advantages and manage their limitations. Understanding these nuances can provide a critical edge in the competitive industry of specialized shipbuilding. Together, these results create a more comprehensive understanding of the shipbuilding industry of specialized ships, identifying key factors that affect production and delivery time and measuring their impact. This research will thus fill a gap in the literature, providing quantitative insights to complement existing literature. Additionally, this research can offer invaluable strategic insights for shipyards seeking to enhance their competitive edge by understanding how factors associated with Build Location can impact time performance.

6.2 Limitations and suggestions for further research

This study has investigated specialized shipbuilding and showed how some factors related to build location affect time performance. The author is to the best of his knowledge not aware of any previous research examining and comparing PSV shipbuilding performance between different build locations, focused on production and delivery time. This study affirms the indications of Semini et al. (2023) that hull offshoring can be a viable strategy to reduce costs. In addition, it seems justifiable to conclude that vertical integration of design and market related factors are likely to have a substantial effect on the production and delivery times of PSVs delivered from Chinese shipyards. However, future research should investigate several factors that could explain the differences in time performance between the build locations. Such studies could perhaps compare other similar factors present in several shipbuilding industries, such as this study has done with hull offshoring and vertical integration of design. As this study highlighted how time is correlated with market-related factors, future studies that investigate the effect of production- and supply chain-related aspects should consider assessing man-hours to counteract this correlation.

This study also provides some understanding of how proximity to clusters, offshoring of hull production and offshoring of design capabilities affect production and delivery times of specialized ships, even though it cannot be concluded that these factors decrease or increase shipbuilding times of PSVs. These findings underline the nuanced dynamics in the shipbuilding industry and suggests that several factors, beyond proximity to a cluster, hull- and design offshoring, could be the reasons for differences in production and delivery times of PSVs between countries. Future research should aim to investigate several of the other factors in Table 2.6, which could explain even more of the variance in production and delivery time.

Furthermore, the fact that the ship sample were limited to PSVs could be a limitation of the study. While the fact that the ship sample were limited to PSVs allowed for an in-depth quantitative analysis, the findings may not be directly applicable to other types of ships due to potential disparities in design and complexity. While the support of several of the hypotheses of the study on quantitative grounds seem to implicate that existing literature on specialized ships can be used on an analysis of PSVs, findings of this study is not necessarily generalizable and applicable to the whole specialized shipbuilding industry. Future research should investigate both these and other factors on all work vessels described in appendix A, to fully comprehend what affects the shipbuilding times of specialized ships.

A limitation of this study on the research into proximity to a cluster and design offshoring, could be the chosen countries in the analyses. These results point to the need for further in-depth research, particularly involving a broader geographical focus and enhanced data collection methods. As an example, the shipbuilding industries of Brazil and Netherlands are also known for cluster exploitation. Further research could focus on or include these countries in the proximity to cluster analysis. As mentioned in the discussion, the data collection method is a potential limitation and could worst case have clobbered the results. Also, the need for a deeper understanding of the dynamics between shipyards and offshore design companies is clear. While potential inefficiencies might exist due to factors such as communication and coordination, these may be offset by other factors like established collaborative relationships. Nevertheless, due to potential limitations in the data collection process, these findings warrant further investigation with a more rigorous research design.

It should be noted that the presence of outliers any potential deviation from the assumptions underlying multiple regression analysis could result in misleading estimations, which could be a potential limitation of the study's results. Additionally, in-depth case studies could offer valuable qualitative insights to complement the quantitative analysis in this and other studies. This research, despite its limitations, provides a foundation for future studies to build upon. Its findings can serve as the basis for more extensive investigations into the specialized shipbuilding industry and the various factors influencing production and delivery times.

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Appendix

Appendix A – Statcode 5 shiptype coding system

Level 5	Level 4	Level 3	Level 2	Level 1
LNG Tanker	LNG Tanker	Liquefied Gas	Tankers	Cargo Carrying Ship Structures
LPG Tanker	LPG Tanker			
LPG/Chemical Tanker				
CO2 Tanker	CO2 Tanker			
Molten Sulphur Tanker	Chemical Tanker	Chemical		
Chemical Tanker				
Chemical/Products Tanker	Chemical/Oil Products Tanker			
Wine Tanker	Wine Tanker			
Vegetable Oil Tanker	Vegetable Oil Tanker			
Edible Oil Tanker	Edible Oil Tanker			
Beer Tanker	Beer Tanker			
Latex Tanker	Latex Tanker			
Shuttle Tanker	Crude Oil Tanker	Oil		
Crude Oil Tanker				
Crude/Oil Products Tanker				
Products Tanker	Oil Products Tanker			
Tanker (unspecified)				
Asphalt/Bitumen Tanker	Bitumen Tanker			
Coal/Oil Mixture Tanker	Coal/Oil Mixture Tanker			
Water Tanker	Water Tanker	Other Liquids		
Molasses Tanker				
Glue Tanker	Glue Tanker			
Alcohol Tanker	Alcohol Tanker			
Caprolactam Tanker	Caprolactam Tanker			
Fruit Juice Tanker	Fruit Juice Tanker			
Bulk Carrier	Bulk Carrier	Bulk Dry	Bulk Carriers	
Bulk Carrier, Laker Only				
Bulk Carrier (with Vehicle Decks)				
Ore Carrier	Ore Carrier			
Bulk/Oil Carrier (OBO)	Bulk/Oil Carrier	Bulk Dry/Oil		
Ore/Oil Carrier	Ore/Oil Carrier			
Bulk Cargo Carrier, self discharging	Self Discharging Bulk Carrier	Self Discharging Bulk Dry		
Bulk Cargo Carrier, self discharging, Laker				
Cement Carrier	Cement Carrier	Other Bulk Dry		
Wood Chips Carrier, self unloading	Wood Chips Carrier			
Urea Carrier	Urea Carrier			
Aggregates Carrier	Aggregates Carrier			
Limestone Carrier	Limestone Carrier			
Refined Sugar Carrier	Refined Sugar Carrier			

Level 5	Level 4	Level 3	Level 2	Level 1	
Powder Carrier	Powder Carrier	Other Bulk Dry	Bulk Carriers	Cargo Carrying	Ship Structures
General Cargo Ship (with Ro-Ro facility) General Cargo, Self-discharging Open Hatch cargo Ship General Cargo/Tanker (Container/oil/ bulk - COB ship) General Cargo/Tanker General Cargo Ship	General Cargo Ship	General Cargo	Dry/Cargo/Passenger		
Palletised Cargo Ship	Palletised Cargo Ship				
Deck Cargo Ship	Deck Cargo Ship				
General Cargo/Passenger Ship	Passenger/General Cargo Ship	Passenger/General Cargo Ship			
Container Ship (Fully Cellular) Container Ship (Fully Cellular with Ro-Ro Facility)	Container Ship	Container			
Passenger/Container Ship	Passenger/Container Ship				
Refrigerated Cargo Ship	Refrigerated Cargo Ship	Refrigerated Cargo Ship			
Ro-Ro Cargo Ship Rail Vehicles Carrier	Ro-Ro Cargo Ship	Ro-Ro Cargo			
Vehicles Carrier	Vehicles Carrier				
Container/Ro-Ro Cargo Ship	Container/Ro-Ro Cargo Ship				
Landing Craft	Landing Craft				
Passenger/Ro-Ro Ship (Vehicles) Passenger/Ro-Ro Ship (Vehicles/Rail)	Passenger/Ro-Ro Cargo Ship	Passenger/Ro-Ro Cargo			
Passenger/Landing Craft	Passenger/Landing Craft				
Passenger/Cruise	Passenger (Cruise) Ship	Passenger			
Passenger Ship	Passenger Ship				
Livestock Carrier	Livestock Carrier	Other Dry Cargo			
Barge Carrier	Barge Carrier				
Heavy Load Carrier Heavy Load Carrier, semi submersible Yacht Carrier, semi submersible	Heavy Load Carrier				
Nuclear Fuel Carrier Nuclear Fuel Carrier (with Ro-Ro facility)	Nuclear Fuel Carrier				
Pulp Carrier	Pulp Carrier	Fish Catching	Fishing		
Factory Stern Trawler Stern Trawler Trawler	Trawler				
Fishing Vessel	Fishing Vessel				

Level 5	Level 4	Level 3	Level 2	Level 1	
Fish Factory Ship	Fish Factory Ship	Other Fishing	Fishing	Work Vessel	Ship Structures
Fish Carrier	Fish Carrier				
Live Fish Carrier (Well Boat)	Live Fish Carrier				
Fish Farm Support Vessel Fishery Patrol Vessel Fishery Research Vessel Fishery Support Vessel	Fish Farm Support Vessel				
Seal Catcher	Seal Catcher				
Whale Catcher	Whale Catcher				
Kelp Dredger	Kelp Dredger				
Pearl Shells Carrier	Pearl Shells Carrier				
Crew/Supply Vessel Pipe Carrier Platform Supply Ship	Platform Supply Ship	Offshore Supply	Offshore		
Anchor Handling Tug Supply Offshore Tug/Supply Ship	Offshore Tug/Supply Ship				
Offshore Support Vessel Diving Support Vessel Accommodation Ship	Offshore Support Vessel	Other Offshore			
Drilling Ship	Drilling Ship				
Pipe Layer Crane Vessel Pipe Layer	Pipe Layer				
Production Testing Vessel	Production Testing Vessel				
FPSO, Oil Gas Processing Vessel	FPSO				
Well Stimulation Vessel	Well Stimulation Vessel				
Standby Safety Vessel	Standby Safety Vessel				
FSO, Oil	FSO (Floating, Storage, Offloading)				
Trenching Support Vessel	Trenching Support Vessel				
Pipe Burying Vessel	Pipe Burying Vessel				
Research Survey Vessel	Research Vessel	Research	Miscellaneous		
Tug	Tug	Towing/Pushing			
Articulated Pusher Tug Pusher Tug	Pusher Tug				
Bucket Ladder Dredger Cutter Suction Dredger	Dredger	Dredging			

Level 5	Level 4	Level 3	Level 2	Level 1	
Grab Dredger	Dredger	Dredging	Miscellaneous	Work Vessel	Ship Structures
Backhoe Dredger					
Bucket Wheel Suction Dredger					
Suction Dredger					
Dredger (unspecified)					
Bucket Hopper Dredger	Hopper Dredger				
Grab Hopper Dredger					
Suction Hopper Dredger					
Trailing Suction Hopper Dredger					
Hopper/Dredger (unspecified)					
Hopper, Motor	Motor Hopper	Other Activities			
Stone Carrier					
Crane Ship	Crane Ship				
Pile Driving Vessel					
Icebreaker	Icebreaker				
Icebreaker/Research					
Cable Repair Ship	Cable Layer				
Cable Layer					
Incinerator	Waste Disposal Vessel				
Waste Disposal Vessel					
Effluent carrier					
Fire Fighting Vessel	Fire Fighting Vessel				
Pollution Control Vessel	Pollution Control Vessel				
Patrol Vessel	Patrol Vessel				
Crew Boat	Crew Boat				
Training Ship	Training Ship				
Utility Vessel	Utility Vessel				
Search & Rescue Vessel	Search & Rescue Vessel				
Pilot Vessel	Pilot Vessel				
Salvage Ship	Salvage Ship				
Buoy Tender	Buoy/Lighthouse Vessel				
Buoy & Lighthouse Tender					
Lighthouse Tender					
Supply Tender	Supply Tender				
Mooring Vessel	Mooring Vessel				

Level 5	Level 4	Level 3	Level 2	Level 1	
Work/Repair Vessel	Work/Repair Vessel	Other Activities	Miscellaneous	Work Vessel	Ship Structures
Hospital Vessel	Hospital Vessel				
Tank Cleaning Vessel	Tank Cleaning Vessel				
Trans Shipment Vessel	Trans Shipment Vessel				
Anchor handling Vessel	Anchor Hoy				
Log Tipping Ship	Log Tipping Ship				
Bunkering Tanker	Bunkering Tanker				
Exhibition Vessel Theatre Vessel Mission Ship	Leisure Vessels				
Bulk Dry Storage Ship Bulk Cement Storage Ship	Dry Storage				
Mining Vessel	Mining Vessel				
Power Station Vessel	Power Station Vessel				
Vessel (function unknown)	Vessel (function unknown)				
Sailing Vessel	Sailing Vessel				

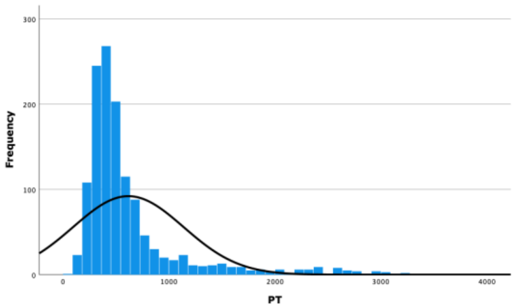
Appendix B – Specialization project results

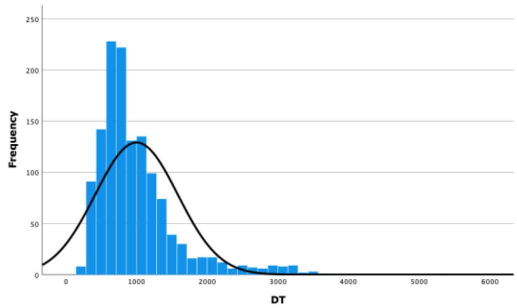
Main elements affecting shipbuilding	USA	China	Romania	Brazil	Norway	India	Poland
Product volume and variety	The definitive smallest ship sizes of PSVs, in terms of average length and GT.	Varying ship types. Known for repeat production. Primarily big ships. Container-, bulker- and tanker vessels of different sizes.	Diversified order book, high variety. Most hull production, for complex, specialized ships. Large ships, especially in terms of PSV.	High volumes of specialized complex vessels. Some product variety.	Low volumes with low variety. Specialized, complex ships. Large PSVs. Offshoring hull production.	Primarily low volumes. High variety of ships, ranging from smaller, high-value vessels to large vessels in large quantities. Small PSVs compared to other countries.	Low volumes, with moderate variety in products. Large ship hulls for outsourcing (PSVs). Traditionally large ships for full domestic completion.
Workforce	Low productivity and competitiveness in general.	Low labor costs, with growing skill. Low productivity compared to leading Asian workforces (example Japan).	Qualified, skilled workforce capable of constructing specialized ships.	Low productivity.	High labor costs. Very productive workforce.	Low productivity, cheap labor.	Skilled, with the ability to produce hulls for complex vessels.
Industrial environment (with VI)	Large domestic industry.	Large industry, with extensive vertical integration and R&D.	Medium industry size. Low vertical integration. Equipment and machinery must be imported.	Medium size. Domestic engineering, production of equipment and steel available.	Small to medium industry. Focus on R&D and design, innovation and engineering.	Growing industry. Low vertical integration. Troublesome communication between design, planning, scheduling, and production departments.	Small industry. Some proximity between ship and steel production, and R&D-facilities.
Design capabilities	Unknown.	Design capabilities integrated in shipyards, or integrated in the supply chain through parent company. PSVs often designed in (for example) Norway.	Strong design capabilities for the ship's bodies.	Unknown.	Strong design capabilities, some integrated in the shipyards.	Design processes is outsourced.	Design often done by other countries who order the hulls.
Clusters	Unknown.	Several big and some smaller clusters.	No clusters found.	Cluster consentrations in the south-east, exploiting synergies. One cluster in the north-east.	One main, highly developed cluster.	As suppliers are located abroad, ancillary industries are underdeveloped and thus synergies are not exploited through clusters.	Industry located in clusters.
Yard size	Unknown.	A large variety in yard sizes, from very large to smaller yards. Known for some of its huge shipyards in comparison to other countries.	Although there is limited information available about yard size, Romania is known for large production capabilities.	Unknown.	Small to medium size yards.	Unknown.	Small to medium size yards.

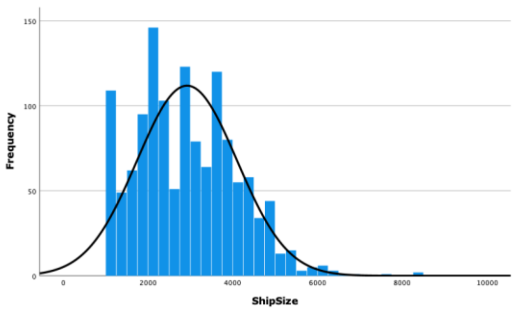
Appendix C – Univariate examinations

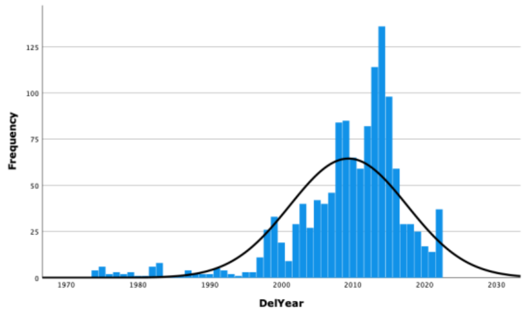
Histograms

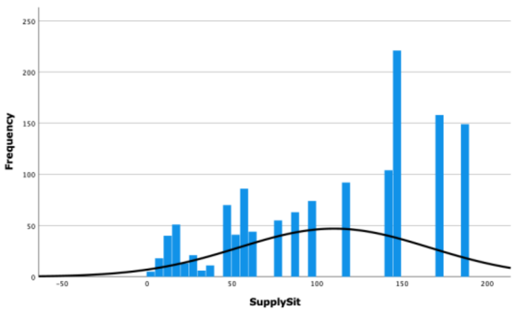
Build Location Model

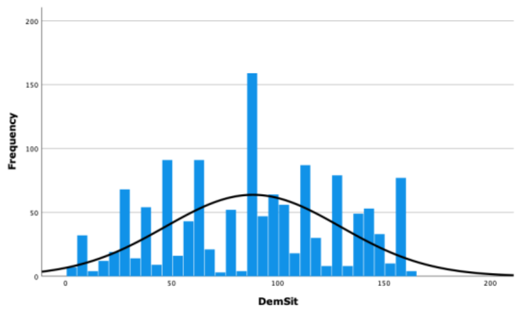


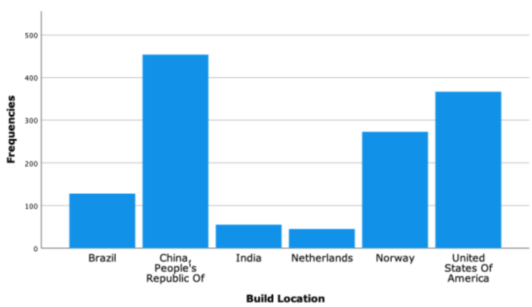




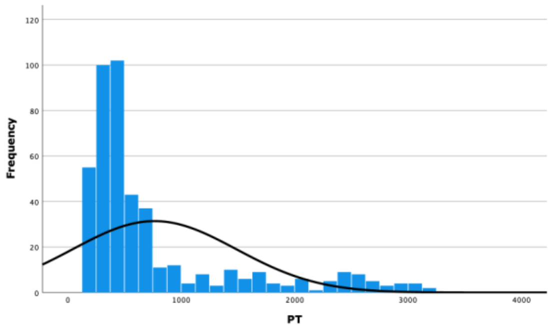


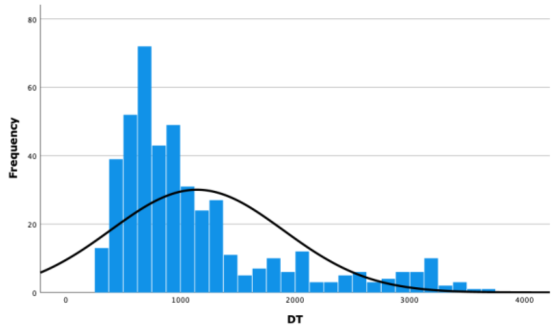


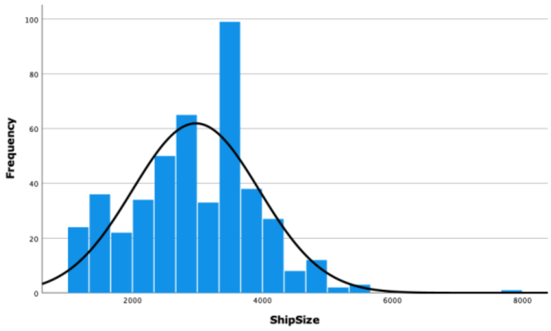


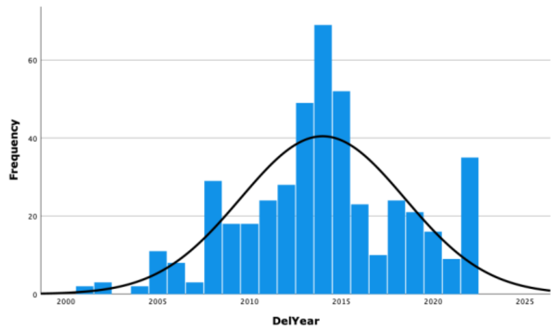


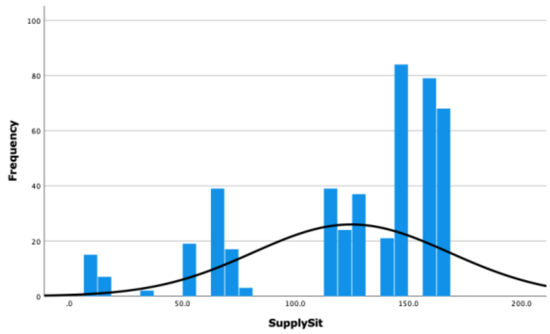
Cluster model

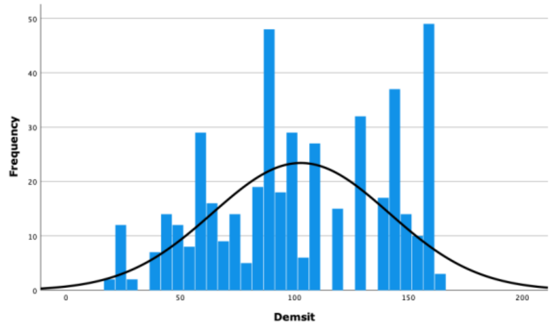


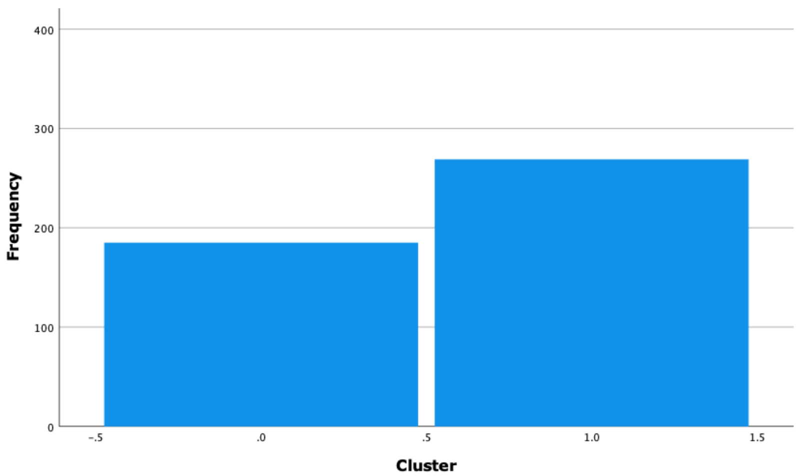




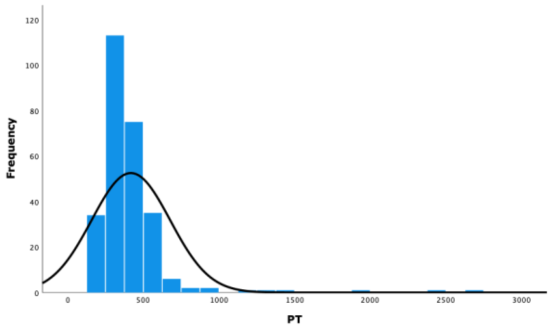


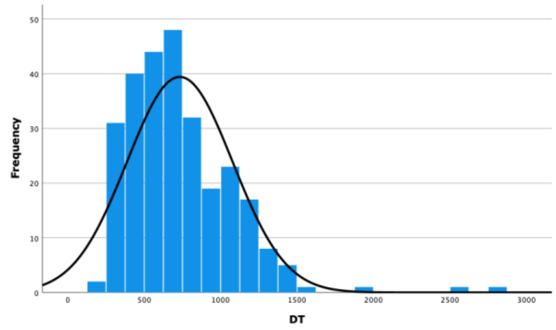


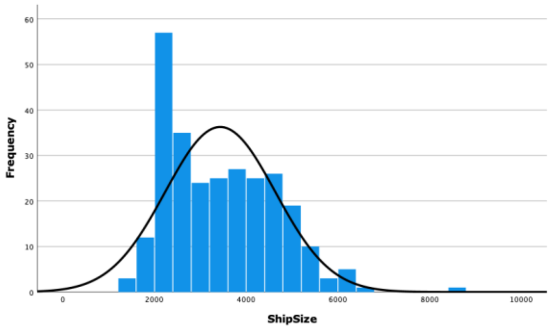


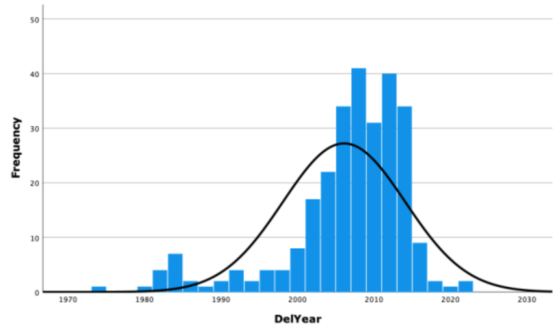


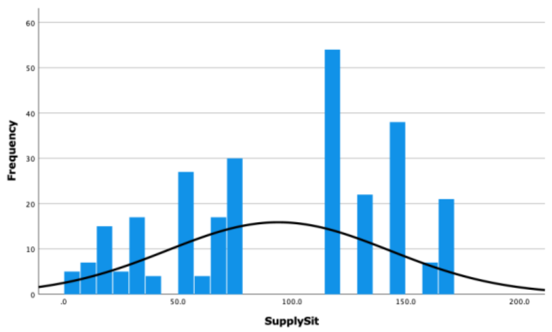
Hull Offshoring model

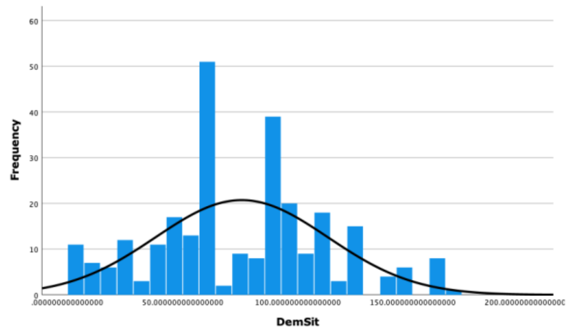


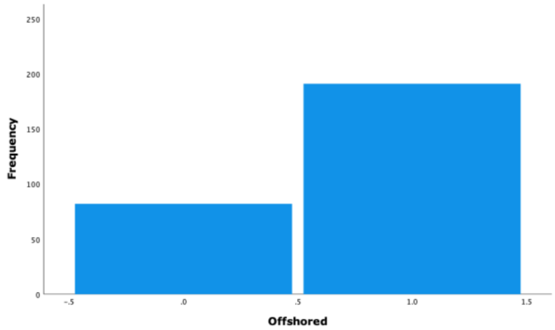




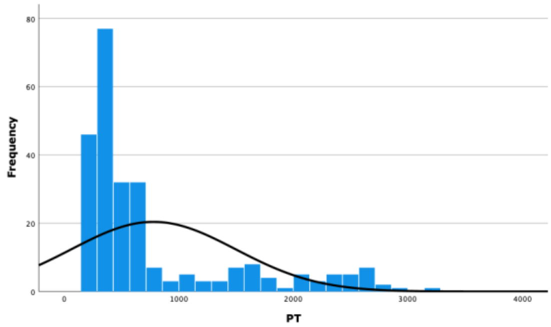


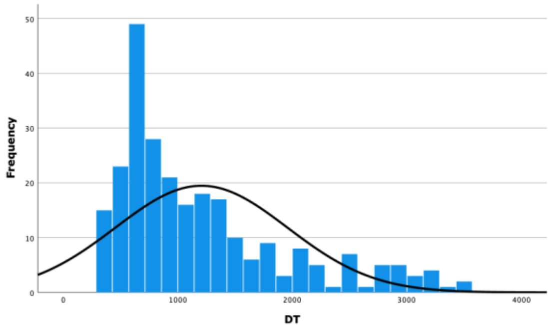


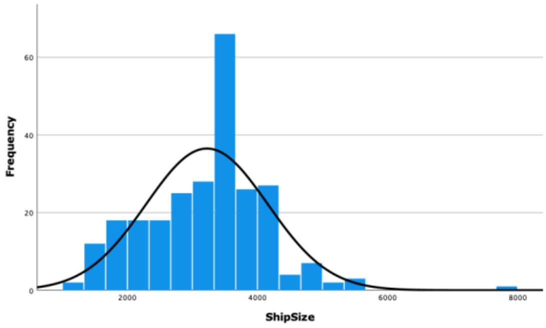


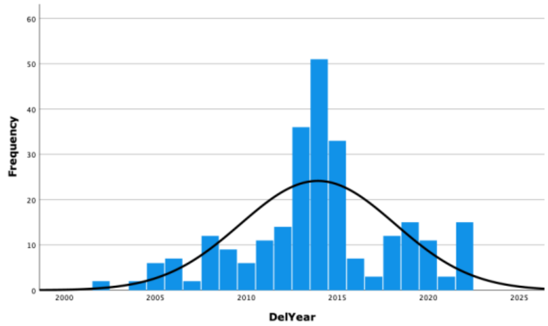


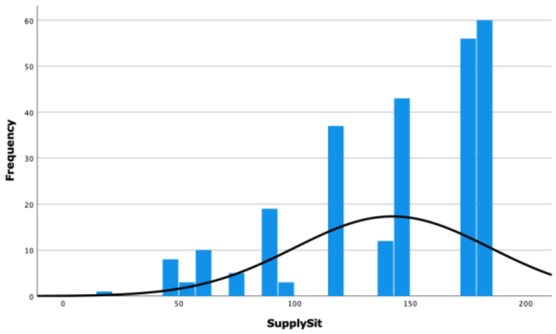
Design Offshoring model

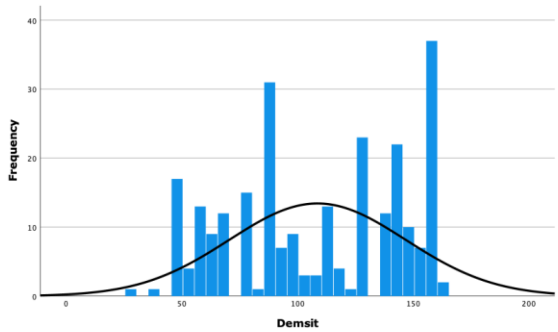


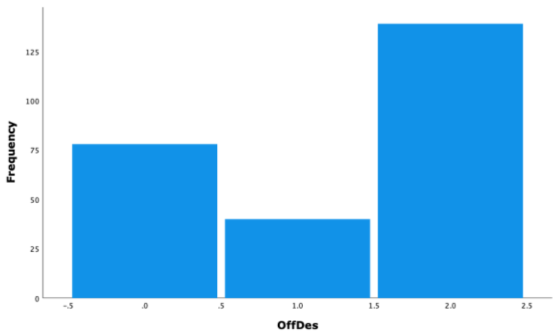




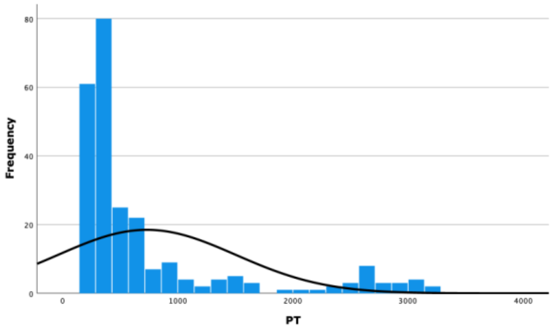


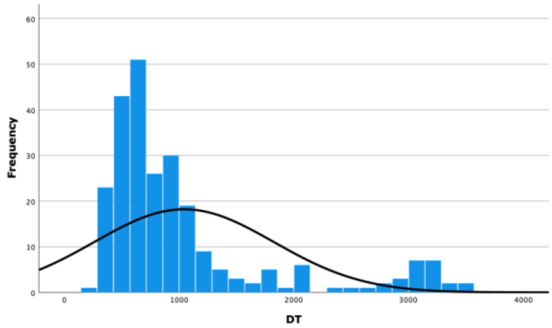


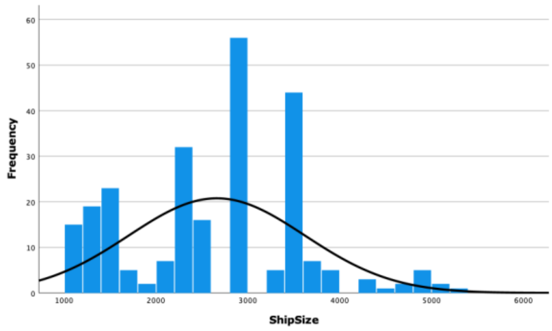


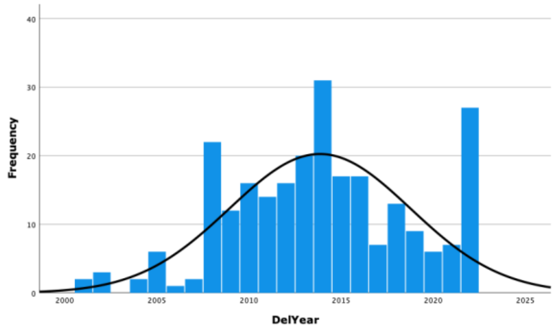


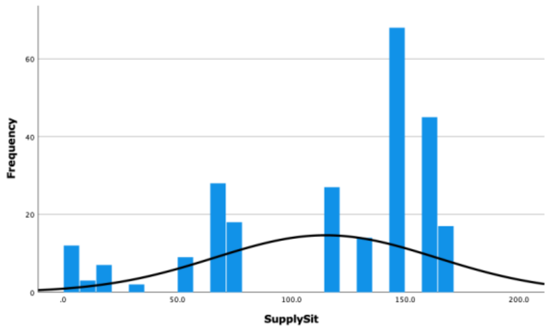
Vertical Integration of Design model

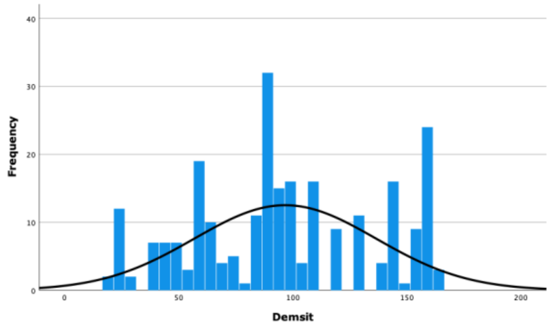


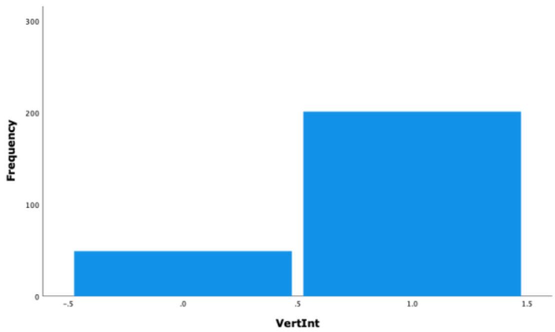












Appendix D – Bivariate examinations

Build Location model

Pearson's Correlations	PT	ShipSize	DelYear	SupplySit	DemSit	Brazil	China	India	Netherlands	Norway	USA
PT	1	.199**	.428**	.169**	-.094**	-.041	.204**	.077**	-.061*	-.197**	-.022
ShipSize	.199**	1	.421**	.345**	.320**	.067*	.033	-.049	-.052	.222**	-.237**
DelYear	.428**	.421**	1	.594**	.584**	-.013	.409**	.021	-.104**	-.204**	-.209**
SupplySit	.169**	.345**	.594**	1	.772**	-.056*	.234**	.005	.035	-.126**	-.114**
DemSit	-.094**	.320**	.584**	.772**	1	-.013	.254**	.048	-.008	-.153**	-.141**
Brazil	-.041	.067*	-.013	-.056*	-.013	1	-.237**	-.068*	-.061*	-.167**	-.203**
China	.204**	.033	.409**	.234**	.254**	-.237**	1	-.151**	-.136**	-.369**	-.448**
India	.077**	-.049	.021	.005	.048	-.068*	-.151**	1	-.039	-.106**	-.129**
Netherlands	-.061*	-.052	-.104**	.035	-.008	-.061*	-.136**	-.039	1	-.096**	-.116**
Norway	-.197**	.222**	-.204**	-.126**	-.153**	-.167**	-.369**	-.106**	-.096**	1	-.316**
USA	-.022	-.237**	-.209**	-.114**	-.141**	-.203**	-.448**	-.129**	-.116**	-.316**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

Listwise N=1322

Pearson's Correlations	DT	ShipSize	DelYear	SupplySit	DemSit	Brazil	China	India	Netherlands	Norway	USA
DT	1	.121**	.223**	.081**	-.170**	.008	.178**	.115**	-.047	-.234**	-.014
ShipSize	.121**	1	.421**	.345**	.320**	.067*	.033	-.049	-.052	.222**	-.237**
DelYear	.223**	.421**	1	.594**	.584**	-.013	.409**	.021	-.104**	-.204**	-.209**
SupplySit	.081**	.345**	.594**	1	.772**	-.056*	.234**	.005	.035	-.126**	-.114**
DemSit	-.170**	.320**	.584**	.772**	1	-.013	.254**	.048	-.008	-.153**	-.141**
Brazil	.008	.067*	-.013	-.056*	-.013	1	-.237**	-.068*	-.061*	-.167**	-.203**
China	.178**	.033	.409**	.234**	.254**	-.237**	1	-.151**	-.136**	-.369**	-.448**
India	.115**	-.049	.021	.005	.048	-.068*	-.151**	1	-.039	-.106**	-.129**
Netherlands	-.047	-.052	-.104**	.035	-.008	-.061*	-.136**	-.039	1	-.096**	-.116**
Norway	-.234**	.222**	-.204**	-.126**	-.153**	-.167**	-.369**	-.106**	-.096**	1	-.316**
USA	-.014	-.237**	-.209**	-.114**	-.141**	-.203**	-.448**	-.129**	-.116**	-.316**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N=1322

Cluster model

Pearson's Correlations	PT	ShipSize	DelYear	SupplySit	DemSit	Cluster
PT	1	.300**	.690**	.137**	-.471**	.204**
ShipSize	.300**	1	.349**	.309**	.089	-.088
DelYear	.690**	.349**	1	.173**	-.142**	.174**
SupplySit	.137**	.309**	.173**	1	.625**	-.150**
DemSit	-.471**	.089	-.142**	.625**	1	-.244**
Cluster	.204**	-.088	.174**	-.150**	-.244**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N=454

Pearson's Correlations	DT	ShipSize	DelYear	SupplySit	DemSit	Cluster
DT	1	.344**	.629**	.159**	-.467**	.129**
ShipSize	.344**	1	.349**	.309**	.089	-.088
DelYear	.629**	.349**	1	.173**	-.142**	.174**
SupplySit	.159**	.309**	.173**	1	.625**	-.150**
DemSit	-.467**	.089	-.142**	.625**	1	-.244**
Cluster	.129**	-.088	.174**	-.150**	-.244**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N=454

Hull Offshoring model

Pearson's Correlations	PT	ShipSize	DelYear	SupplySit	DemSit	Hull Offshoring
PT	1	.306**	.335**	.277**	.172**	.180**
ShipSize	.306**	1	.445**	.354**	.373**	.127*
DelYear	.335**	.445**	1	.709**	.713**	.465**
SupplySit	.277**	.354**	.709**	1	.864**	.281**
DemSit	.172**	.373**	.713**	.864**	1	.290**
Hull Offshoring	.180**	.127*	.465**	.281**	.290**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N = 273

Pearson's Correlations	DT	ShipSize	DelYear	SupplySit	DemSit	Hull Offshoring
DT	1	.141*	-.020	.099	.089	.047
ShipSize	.141*	1	.445**	.354**	.373**	.127*
DelYear	-.020	.445**	1	.709**	.713**	.465**
SupplySit	.099	.354**	.709**	1	.864**	.281**
DemSit	.089	.373**	.713**	.864**	1	.290**
Hull Offshoring	.047	.127*	.465**	.281**	.290**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N = 273

Design Offshoring model

Pearson's Correlations	PT	ShipSize	DelYear	SupplySit	DemSit	Design Offshoring
PT	1	.304**	.742**	.111	-.575**	.063
ShipSize	.304**	1	.351**	.165**	-.059	.387**
DelYear	.742**	.351**	1	.439**	-.062	.017
SupplySit	.111	.165**	.439**	1	.541**	-.026
DemSit	-.575**	-.059	-.062	.541**	1	-.083
Design Offshoring	.063	.387**	.017	-.026	-.083	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N = 257

Pearson's Correlations	DT	ShipSize	DelYear	SupplySit	DemSit	Design Offshoring
DT	1	.387**	.684**	.078	-.571**	.160*
ShipSize	.387**	1	.351**	.165**	-.059	.387**
DelYear	.684**	0**	1.000	.439**	-.062	.017
SupplySit	.078	.165**	.439**	1	.541**	-.026
DemSit	-.571**	-.059	-.062	.541**	1	-.083
Design Offshoring	.160*	.387**	.017	-.026	-.083	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N = 257

Vertical Integration of Design model

Pearson's Correlations	PT	ShipSize	DelYear	SupplySit	DemSit	VertInt
PT	1	.300**	.675**	.117	-.432**	.106
ShipSize	.300**	1	.461**	.356**	.233**	.056
DelYear	.675**	.461**	1	.040	-.194**	-.132*
SupplySit	.117	.356**	.040	1	.683**	.479**
DemSit	-.432**	.233**	-.194**	.683**	1	.305**
VertInt	.106	.056	-.132*	.479**	.305**	1

**Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

N = 250

Pearson's Correlations	DT	ShipSize	DelYear	SupplySit	DemSit	VertInt
DT	1	.274**	.626**	.122	-.459**	.114
ShipSize	.274**	1	.461**	.356**	.233**	.056
DelYear	.626**	.461**	1	.040	-.194**	-.132*
SupplySit	.122	.356**	.040	1	.683**	.479**
DemSit	-.459**	.233**	-.194**	.683**	1	.305**
VertInt	.114	.056	-.132*	.479**	.305**	1

**Correlation is significant at the 0.01 level (2-tailed).

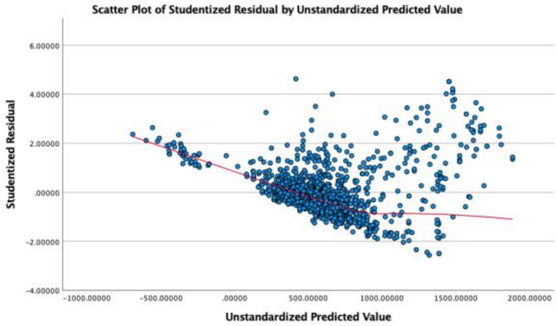
*Correlation is significant at the 0.05 level (2-tailed).

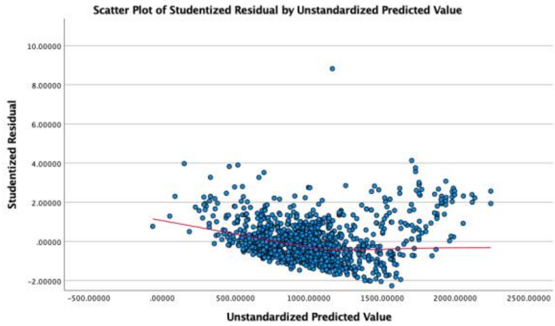
N = 250

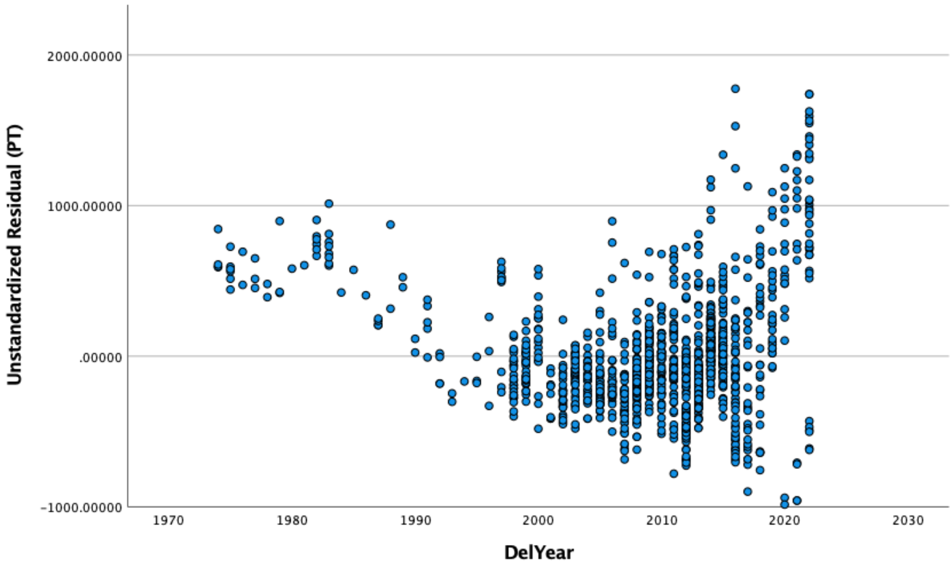
Appendix E – Assumption Investigation

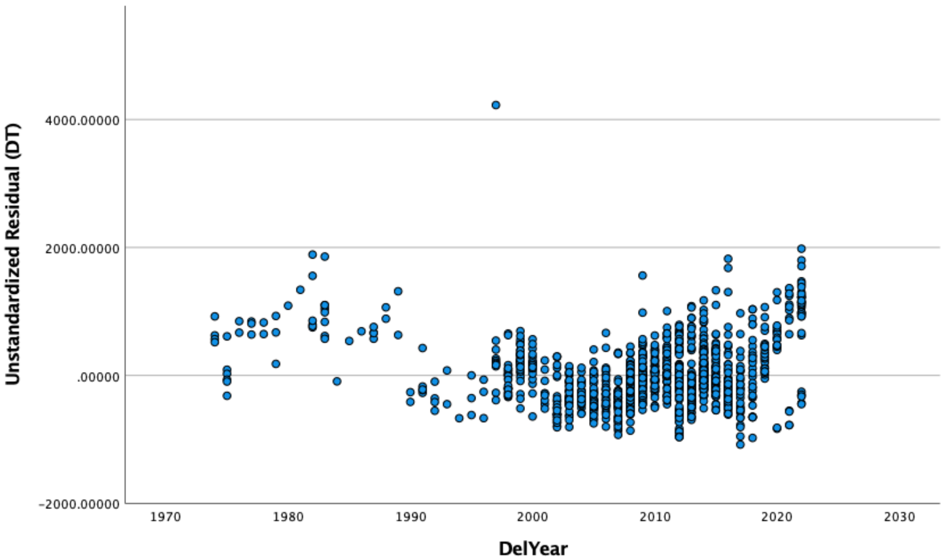
Scatterplots

Build Location model

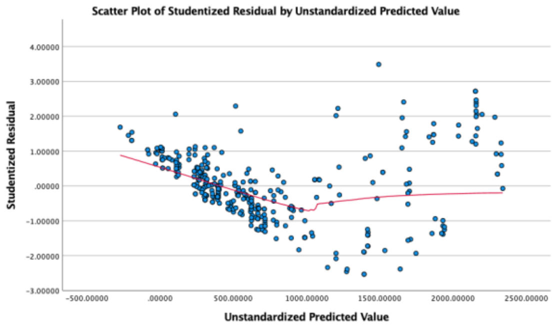


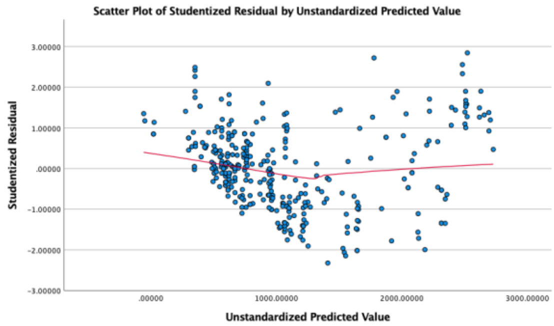




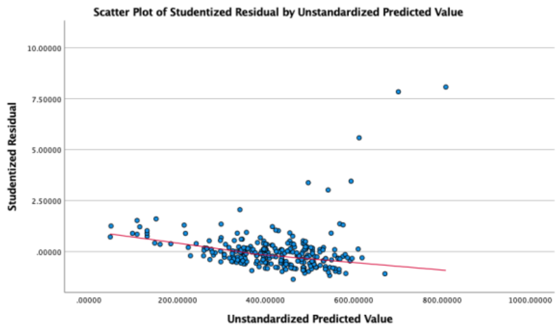


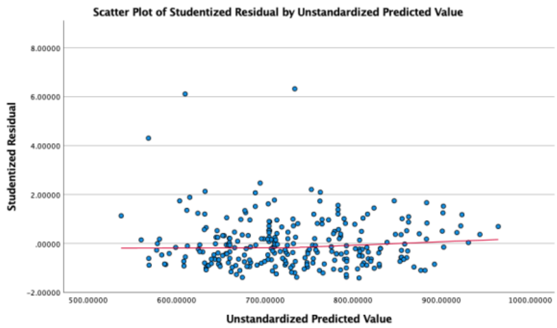
Cluster model



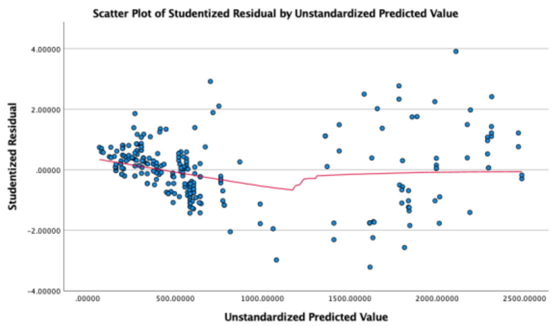


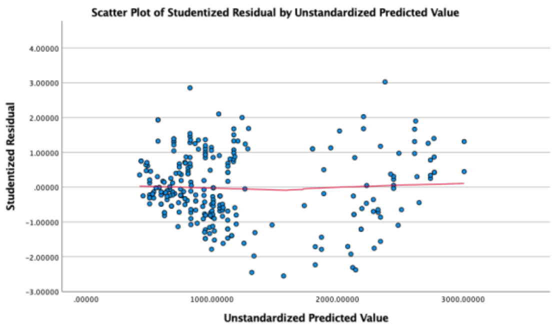
Hull Offshoring model



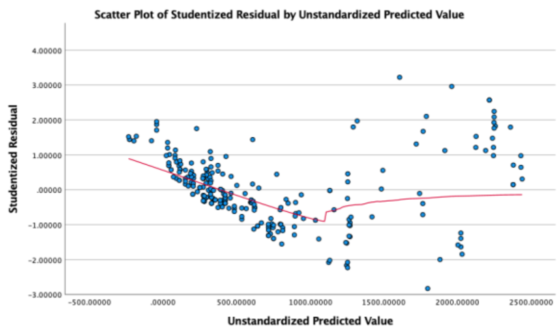


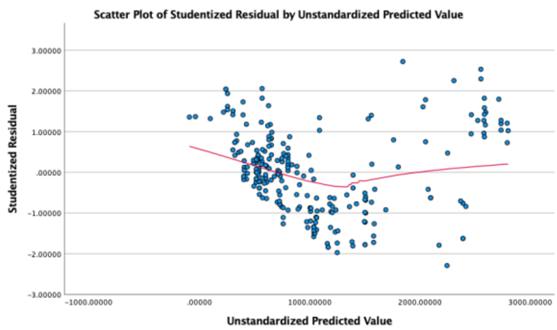
Design Offshoring model





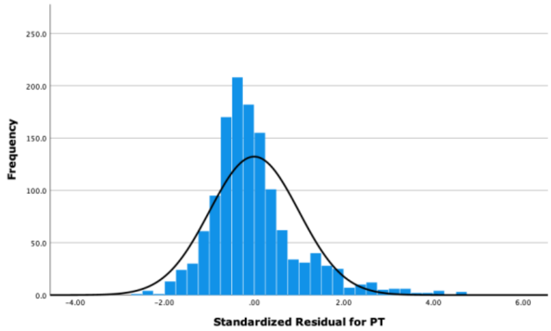
Vertical Integration of Design model

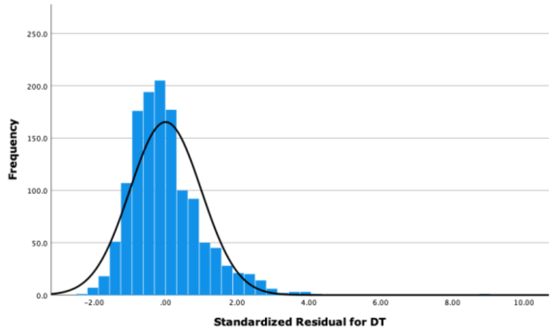




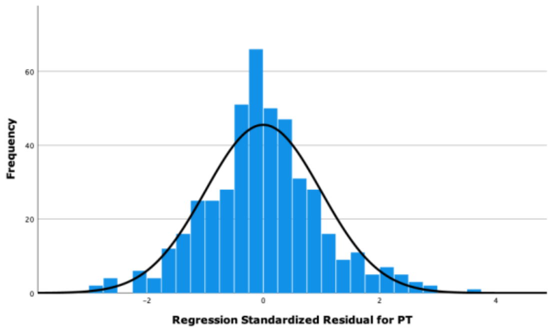
Histograms

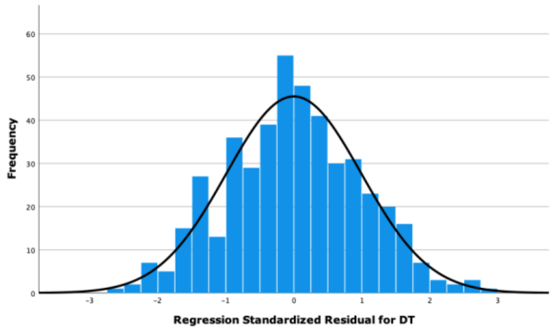
Build Location model



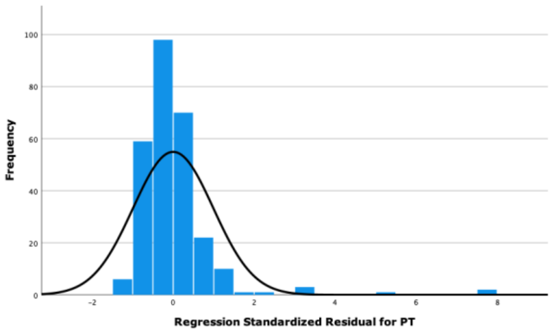


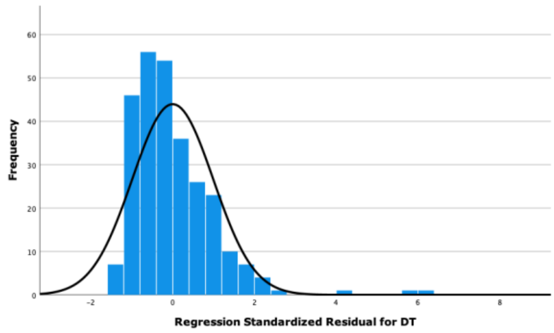
Cluster model



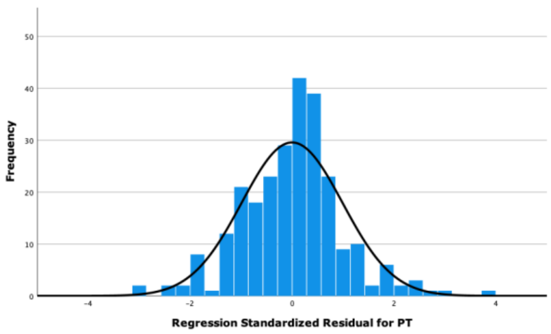


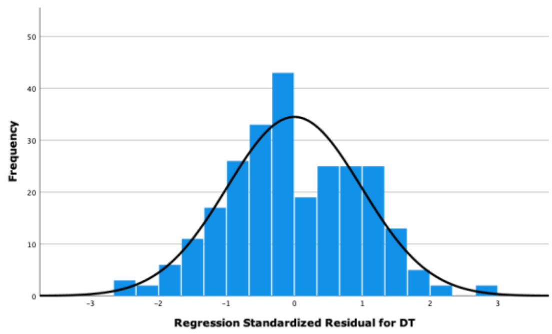
Hull Offshoring model



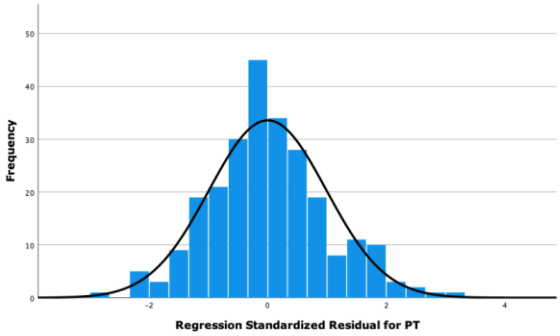


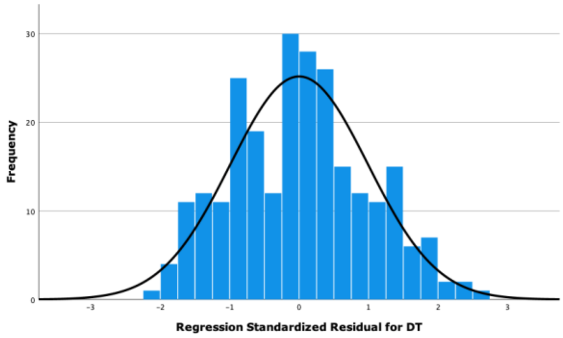
Design Offshoring model





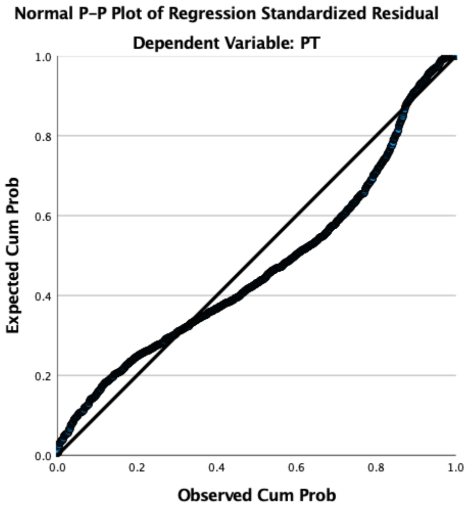
Vertical Integration of Design model

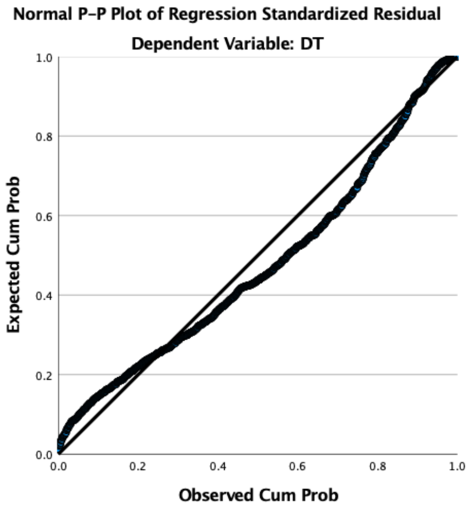




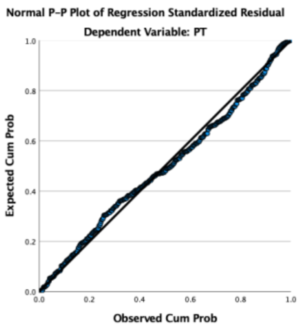
Normal probability plots

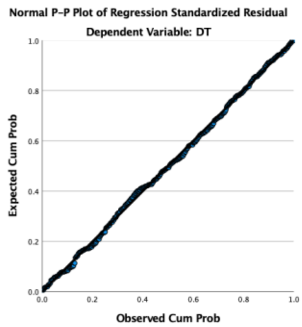
Build Location model



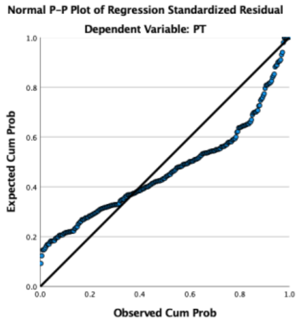


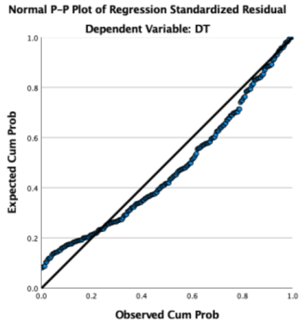
Cluster model



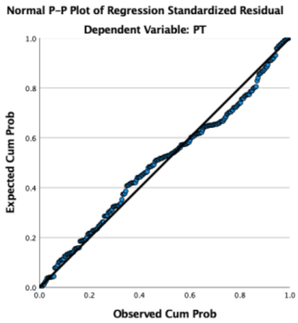


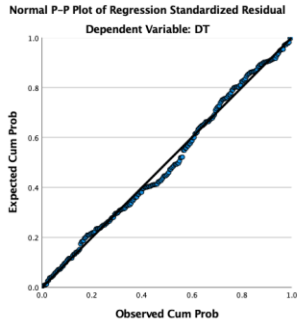
Hull Offshoring model



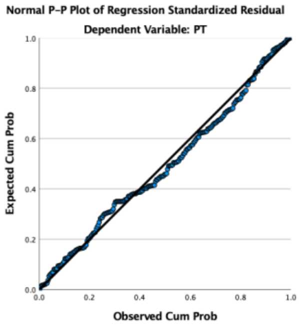


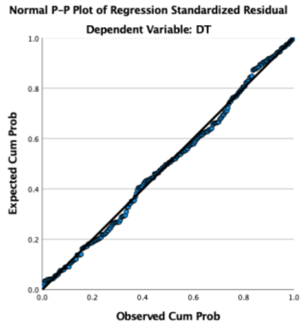
Design Offshoring model





Vertical Integration of Design model





Appendix F – Data sample

IMO/LR/IHS No.	Build Location	GT	DelYear	PT	DT	SupplySit	DemSit
9644146	Brazil	4281	2013	334	1004	185	127
9271767	Brazil	2647	2003	304	455	54	48
9325752	Brazil	2308	2005	395	700	60	50
9357169	Brazil	2143	2007	396	700	96	64
8501880	Brazil	1004	1988	519	2041	23	6
8501892	Brazil	1004	1989	700	1550	4	6
9273301	Brazil	2153	2003	304	1065	54	57
8501907	Brazil	1047	1989	700	2314	23	6
8501830	Brazil	1004	1987	334	1489	23	10
8501854	Brazil	1004	1987	334	1583	23	10
9635523	Brazil	2025	2016	2192	2375	76	111
9630705	Brazil	2025	2013	1096	1310	76	106
8501842	Brazil	1047	1987	365	1581	23	10
9573256	Brazil	4106	2012	243	547	185	90
9440693	Brazil	2633	2009	395	1006	142	111
9620308	Brazil	3606	2011	457	546	76	86
9644160	Brazil	3606	2012	457	730	76	90
9687368	Brazil	3606	2013	457	548	185	127
9610602	Brazil	3606	2011	486	516	58	94
9664299	Brazil	3606	2012	397	458	185	90
9664304	Brazil	3902	2013	366	580	185	127
9698719	Brazil	3606	2014	426	731	148	140
9690432	Brazil	3606	2013	426	487	148	127
9763760	Brazil	4610	2016	851	1065	173	118
9644213	Brazil	3606	2012	458	882	76	90
9703667	Brazil	4610	2015	638	881	173	147
9944417	Brazil	4224	2022	2007	2160	15	36
9678135	Brazil	3983	2015	852	1125	148	147
9678147	Brazil	3983	2017	1155	1581	148	99
9680176	Brazil	3606	2013	334	425	148	127
9328687	Brazil	2046	2005	517	913	45	50
9529786	Brazil	2999	2009	578	1004	145	111
9423205	Brazil	2999	2008	639	1035	96	76
9423231	Brazil	2999	2008	517	790	145	76
9365556	Brazil	2278	2007	516	608	96	63
9423217	Brazil	2999	2007	426	822	96	64
9565651	Brazil	2668	2011	547	730	58	94
9766621	Brazil	4085	2016	519	853	115	95
9426984	Brazil	2668	2010	396	792	89	101
9477402	Brazil	2668	2010	304	1155	142	101
9364306	Brazil	2483	2006	395	640	96	61
9627629	Brazil	4172	2013	488	854	185	127
9578907	Brazil	2767	2012	426	761	58	90

9426972	Brazil	2668	2010	457	822	89	101
9231729	Brazil	1987	2000	489	1461	26	30
9477397	Brazil	2668	2009	395	1004	142	111
9578892	Brazil	4063	2012	427	1096	58	90
9578880	Brazil	4063	2012	488	974	58	90
9318412	Brazil	3066	2005	578	851	45	52
9627631	Brazil	4172	2014	607	1096	185	140
9454008	Brazil	3165	2009	457	731	142	111
9715579	Brazil	4085	2016	396	1004	173	95
9482378	Brazil	3037	2008	457	700	142	90
9715567	Brazil	4085	2016	517	882	173	118
9578919	Brazil	2767	2012	517	882	58	90
9565663	Brazil	2668	2011	427	671	58	94
9231731	Brazil	1987	2001	427	976	13	25
9364318	Brazil	2483	2007	485	791	96	64
9249726	Brazil	1987	2002	426	426	54	28
9556600	Brazil	2429	2011	242	1308	89	86
9423190	Brazil	3230	2007	334	730	96	64
9630327	Brazil	5532	2017	2223	2496	185	104
9667590	Brazil	4748	2016	1370	1552	148	122
7911791	Brazil	1106	1983	273	2375	37	47
9328455	Brazil	2927	2006	731	946	45	56
9303508	Brazil	2160	2005	306	488	45	50
9292072	Brazil	2160	2004	335	549	45	49
9414230	Brazil	1103	2006	1005	1065	60	56
9441489	Brazil	1103	2007	1125	1277	60	58
9441491	Brazil	1103	2008	1066	1186	96	72
9642588	Brazil	3898	2016	670	1978	185	118
9294082	Brazil	3760	2006	730	1035	45	56
9294094	Brazil	3760	2006	822	1188	45	56
9271755	Brazil	2151	2003	487	942	54	48
9273349	Brazil	2151	2004	306	792	56	49
7911715	Brazil	1106	1982	273	1887	37	63
9788459	Brazil	4610	2017	731	793	115	76
7911741	Brazil	1106	1982	214	2040	37	80
9365544	Brazil	2470	2006	457	669	96	61
9573440	Brazil	3938	2012	640	1066	58	90
9274862	Brazil	2865	2005	884	1310	56	52
9788461	Brazil	4075	2022	2192	2588	115	36
9440679	Brazil	2429	2009	304	731	142	111
9642590	Brazil	3898	2016	366	2100	185	95
9644134	Brazil	4281	2013	274	974	185	127
9530072	Brazil	2999	2009	457	823	142	111
9530187	Brazil	2999	2010	485	882	89	101
9530199	Brazil	3281	2010	424	790	89	101
9530204	Brazil	3193	2010	335	365	58	101

9497139	Brazil	2999	2009	426	912	145	111
9530175	Brazil	2999	2009	456	884	142	111
9256690	Brazil	2150	2003	393	577	54	48
9424986	Brazil	2429	2008	397	640	145	90
9364332	Brazil	2429	2007	424	638	96	64
9258387	Brazil	1851	2003	304	607	54	48
9424962	Brazil	2429	2008	455	517	145	90
9578660	Brazil	3933	2013	639	1247	58	111
9578672	Brazil	3933	2014	577	1612	58	140
9578933	Brazil	1459	2016	1461	2282	58	122
9271743	Brazil	2151	2002	334	730	54	38
9440681	Brazil	2429	2009	395	853	142	111
9715737	Brazil	4408	2014	426	579	173	160
9759460	Brazil	4404	2015	395	548	115	143
9668738	Brazil	4427	2013	700	912	185	111
9759472	Brazil	4404	2016	366	609	115	95
9806495	Brazil	4404	2017	365	487	15	54
9759484	Brazil	4404	2016	335	700	115	95
9806512	Brazil	4404	2017	457	610	15	54
9715749	Brazil	4408	2015	395	730	173	143
9799082	Brazil	4404	2017	397	488	15	76
9806483	Brazil	4404	2017	396	456	15	54
9668726	Brazil	4403	2013	853	912	185	111
9715751	Brazil	4408	2015	427	853	173	143
9668752	Brazil	4427	2013	395	1065	185	127
9799070	Brazil	4404	2016	305	366	15	95
9715725	Brazil	4408	2014	518	579	173	160
9668740	Brazil	4427	2013	548	1004	185	127
9759496	Brazil	4404	2016	304	761	115	95
9573244	Brazil	4106	2012	305	974	58	90
9763772	Brazil	6763	2016	487	944	173	118
9644122	Brazil	4281	2013	245	762	185	127
9442055	Brazil	2987	2010	214	1279	142	92
9530060	Brazil	2999	2009	488	793	142	111
9442067	Brazil	2987	2011	215	1402	142	86
9307619	Brazil	2927	2007	608	1339	45	63
9307621	Brazil	2927	2009	943	2223	45	97
9307607	Brazil	2927	2006	699	1096	45	56
9644158	Brazil	4281	2014	516	1155	185	140
9709166	China, People's Republic Of	3120	2019	1645	1979	173	76
9533725	China, People's Republic Of	3601	2018	1614	1826	173	97

9441518	China, People's Republic Of	1092	2008	578	670	145	76
9475894	China, People's Republic Of	1092	2008	457	669	142	90
9709142	China, People's Republic Of	3120	2015	579	852	173	143
9744049	China, People's Republic Of	2146	2016	456	670	115	118
9681340	China, People's Republic Of	3781	2014	426	638	148	160
9533684	China, People's Republic Of	3601	2012	336	1766	89	90
9692648	China, People's Republic Of	4983	2022	2404	3468	173	46
9564188	China, People's Republic Of	1517	2009	214	945	142	110
9671967	China, People's Republic Of	3610	2013	245	731	185	127
9630157	China, People's Republic Of	1764	2013	426	731	185	127
9630169	China, People's Republic Of	1764	2013	365	731	185	127
9656474	China, People's Republic Of	3404	2012	578	912	76	90
9539640	China, People's Republic Of	2369	2010	243	1035	142	101
9737917	China, People's Republic Of	3467	2022	2618	2953	173	59
9669988	China, People's Republic Of	3601	2014	424	639	148	160
9664251	China, People's Republic Of	2908	2013	212	425	148	127
9562726	China, People's Republic Of	2441	2010	516	882	89	104

9647019	China, People's Republic Of	3231	2014	424	882	185	160
9720940	China, People's Republic Of	3542	2014	456	668	148	160
9671321	China, People's Republic Of	2526	2014	516	821	148	140
9818424	China, People's Republic Of	1062	2018	424	638	15	38
9783629	China, People's Republic Of	2987	2015	395	487	115	143
9818436	China, People's Republic Of	1182	2018	424	638	15	38
9818448	China, People's Republic Of	1182	2018	424	638	15	38
9818450	China, People's Republic Of	1182	2018	424	638	15	38
9818462	China, People's Republic Of	1182	2018	608	822	15	38
9796183	China, People's Republic Of	3535	2022	2588	2738	15	46
9338931	China, People's Republic Of	1413	2005	365	548	60	50
9363895	China, People's Republic Of	1411	2005	273	701	60	60
9617777	China, People's Republic Of	2899	2012	243	761	76	90
9579779	China, People's Republic Of	2501	2011	457	1065	58	86
9681352	China, People's Republic Of	3601	2014	334	607	148	160
9630133	China, People's Republic Of	1764	2014	671	945	185	140
9661821	China, People's Republic Of	3555	2012	670	761	76	90

9622124	China, People's Republic Of	1093	2012	182	547	185	100
9307449	China, People's Republic Of	2321	2006	334	853	45	61
9394088	China, People's Republic Of	2337	2008	427	792	145	90
9653886	China, People's Republic Of	3147	2013	487	822	185	127
9653941	China, People's Republic Of	3147	2014	549	1157	185	160
9533567	China, People's Republic Of	3601	2011	426	1277	89	86
9366641	China, People's Republic Of	3665	2008	793	1158	96	76
9752981	China, People's Republic Of	4125	2022	2313	2922	115	46
9692600	China, People's Republic Of	3601	2015	699	911	173	147
9744037	China, People's Republic Of	2146	2016	456	670	115	118
9647057	China, People's Republic Of	3474	2018	1918	2588	185	97
9647069	China, People's Republic Of	3474	2018	1857	2588	185	97
9257577	China, People's Republic Of	2308	2001	304	1004	19	19
9257589	China, People's Republic Of	2308	2001	304	1004	19	19
9530125	China, People's Republic Of	3955	2012	1341	1888	142	95
9530113	China, People's Republic Of	4058	2012	1247	1704	142	98
9386706	China, People's Republic Of	4293	2008	366	1004	145	90

9653898	China, People's Republic Of	3147	2014	487	853	185	140
9653915	China, People's Republic Of	3147	2014	547	1004	185	140
9653939	China, People's Republic Of	3147	2014	487	1065	185	160
9653953	China, People's Republic Of	3147	2014	518	1187	185	160
9653965	China, People's Republic Of	3147	2014	488	1157	185	160
9653977	China, People's Republic Of	3147	2014	518	1187	185	160
9654268	China, People's Republic Of	3147	2015	608	1278	185	147
9654270	China, People's Republic Of	3147	2015	638	1308	185	147
9654282	China, People's Republic Of	3147	2015	577	1247	185	147
9654294	China, People's Republic Of	3147	2015	669	1339	185	147
9654309	China, People's Republic Of	3147	2015	577	1278	185	147
9654311	China, People's Republic Of	3147	2015	639	1370	185	147
9654323	China, People's Republic Of	3147	2015	638	1400	185	143
9654335	China, People's Republic Of	3147	2015	577	1370	185	143
9654347	China, People's Republic Of	3147	2015	730	1431	185	147
9530101	China, People's Republic Of	4071	2011	1003	1430	142	98
9394105	China, People's Republic Of	2341	2008	428	884	145	90

9331309	China, People's Republic Of	2321	2006	365	882	60	61
9331323	China, People's Republic Of	2535	2006	365	730	60	61
9331311	China, People's Republic Of	2321	2006	365	668	60	61
9630145	China, People's Republic Of	1764	2013	334	639	185	127
9630092	China, People's Republic Of	1764	2013	640	823	185	111
9630107	China, People's Republic Of	1764	2013	670	853	185	111
9630119	China, People's Republic Of	1764	2013	701	884	185	111
9630080	China, People's Republic Of	1764	2013	670	974	185	111
9630171	China, People's Republic Of	1764	2013	426	792	185	127
9639191	China, People's Republic Of	1764	2014	608	974	185	140
9639206	China, People's Republic Of	1764	2014	639	1005	185	140
9639218	China, People's Republic Of	1764	2014	426	1035	185	160
9639220	China, People's Republic Of	1764	2014	609	1249	185	160
9639232	China, People's Republic Of	1764	2014	518	1249	185	160
9530137	China, People's Republic Of	4058	2013	1522	1949	142	108
9386689	China, People's Republic Of	4293	2008	397	821	145	90
9386691	China, People's Republic Of	4293	2008	366	882	145	90

9512226	China, People's Republic Of	2369	2008	244	700	142	111
9507049	China, People's Republic Of	2554	2010	761	1308	142	104
9697064	China, People's Republic Of	3927	2015	334	789	173	143
9581162	China, People's Republic Of	1517	2010	304	608	58	101
9394428	China, People's Republic Of	1517	2008	305	853	145	90
9394387	China, People's Republic Of	1517	2008	336	882	96	90
9539614	China, People's Republic Of	2369	2009	273	547	89	111
9329930	China, People's Republic Of	7683	2006	638	1247	45	56
9553490	China, People's Republic Of	1571	2009	242	853	142	111
9696929	China, People's Republic Of	3927	2014	457	608	173	160
9679751	China, People's Republic Of	2955	2013	181	426	148	154
9697478	China, People's Republic Of	2955	2014	212	424	173	160
9762780	China, People's Republic Of	2195	2018	1400	1551	115	86
9656486	China, People's Republic Of	3404	2012	640	974	76	90
9533608	China, People's Republic Of	3955	2012	335	1674	89	90
9692636	China, People's Republic Of	4983	2021	2741	3165	173	62
9702883	China, People's Republic Of	4983	2022	2437	3167	173	46

9673159	China, People's Republic Of	2512	2013	304	425	148	127
9694024	China, People's Republic Of	3467	2015	184	671	173	143
9659359	China, People's Republic Of	3370	2014	546	883	148	160
9671333	China, People's Republic Of	2638	2014	457	731	148	140
9555266	China, People's Republic Of	2308	2009	335	639	142	111
9680645	China, People's Republic Of	2948	2013	274	457	148	127
9647045	China, People's Republic Of	4768	2014	395	1096	185	160
9708100	China, People's Republic Of	3535	2014	212	577	148	160
9708112	China, People's Republic Of	3535	2014	212	577	148	160
9726865	China, People's Republic Of	3535	2015	276	427	173	143
9726877	China, People's Republic Of	3535	2015	304	516	173	143
9647033	China, People's Republic Of	5132	2014	396	1035	185	160
9720691	China, People's Republic Of	2030	2022	2618	3014	173	59
9786267	China, People's Republic Of	3147	2015	549	669	115	143
9664249	China, People's Republic Of	2908	2013	304	517	148	127
9765421	China, People's Republic Of	4845	2015	730	791	173	147
9817999	China, People's Republic Of	4833	2017	365	457	15	54

9818008	China, People's Republic Of	4833	2017	334	487	15	39
9818010	China, People's Republic Of	4869	2018	426	518	15	48
9538505	China, People's Republic Of	2308	2009	335	762	145	111
9309722	China, People's Republic Of	1387	2004	335	670	56	49
9437086	China, People's Republic Of	2349	2007	335	669	145	64
9680798	China, People's Republic Of	2946	2014	396	608	148	160
9753246	China, People's Republic Of	1770	2015	334	487	115	121
9753234	China, People's Republic Of	1770	2015	365	487	115	143
9790127	China, People's Republic Of	3220	2016	427	458	15	95
9697167	China, People's Republic Of	2948	2021	2800	3165	173	62
9720768	China, People's Republic Of	3583	2021	2710	3014	173	62
9394375	China, People's Republic Of	1517	2008	305	882	96	90
9471941	China, People's Republic Of	2443	2008	304	1034	96	90
9427110	China, People's Republic Of	4801	2011	883	1673	142	94
9658147	China, People's Republic Of	2987	2013	274	609	148	127
9743069	China, People's Republic Of	3924	2019	1644	2070	115	58
9707572	China, People's Republic Of	3924	2020	1796	2496	173	52

9740744	China, People's Republic Of	3795	2019	1642	1977	173	76
9740756	China, People's Republic Of	3795	2019	1522	1977	173	58
9720756	China, People's Republic Of	3583	2014	214	518	173	165
9366653	China, People's Republic Of	3665	2009	823	1311	96	82
9533622	China, People's Republic Of	3601	2013	275	1827	89	127
9734898	China, People's Republic Of	3991	2016	669	912	115	118
9743708	China, People's Republic Of	2932	2015	424	424	115	143
9764881	China, People's Republic Of	2932	2016	761	881	115	118
9527582	China, People's Republic Of	2426	2009	517	700	142	97
9579767	China, People's Republic Of	2501	2011	426	942	58	86
9557666	China, People's Republic Of	3753	2011	912	1187	89	98
9533581	China, People's Republic Of	3790	2011	365	1430	89	86
9671979	China, People's Republic Of	3553	2013	365	517	148	127
9709154	China, People's Republic Of	3120	2015	579	852	173	143
9539638	China, People's Republic Of	2369	2009	275	700	89	110
9533593	China, People's Republic Of	3601	2012	397	1705	89	90
9755397	China, People's Republic Of	3785	2022	2435	2830	115	46

9727883	China, People's Republic Of	3535	2015	245	427	173	143
9587348	China, People's Republic Of	2921	2010	334	608	58	101
9329916	China, People's Republic Of	5448	2005	640	1005	45	52
9329942	China, People's Republic Of	5448	2006	639	1370	45	56
9543823	China, People's Republic Of	2308	2009	335	578	142	111
9725720	China, People's Republic Of	3800	2020	2039	2527	173	68
9725756	China, People's Republic Of	3800	2020	2008	2557	173	68
9755402	China, People's Republic Of	3785	2022	2588	3014	115	46
9702780	China, People's Republic Of	3800	2020	2102	2467	173	68
9755385	China, People's Republic Of	3785	2022	2557	2861	115	46
9702792	China, People's Republic Of	3800	2020	2010	2436	173	68
9755414	China, People's Republic Of	3785	2021	2283	2740	115	47
9739446	China, People's Republic Of	3608	2018	1341	1433	115	86
9739458	China, People's Republic Of	3612	2022	3075	3167	115	59
9596064	China, People's Republic Of	2226	2011	487	975	89	94
9596076	China, People's Republic Of	2226	2011	607	881	58	94
9679505	China, People's Republic Of	2955	2013	153	396	148	154

9627796	China, People's Republic Of	2955	2013	153	396	148	154
9568665	China, People's Republic Of	2903	2012	213	1613	89	90
9568653	China, People's Republic Of	2900	2012	214	1492	89	90
9394404	China, People's Republic Of	1517	2008	305	943	96	90
9394351	China, People's Republic Of	1517	2008	337	822	96	90
9394416	China, People's Republic Of	1517	2008	274	973	96	90
9394430	China, People's Republic Of	1517	2008	275	1035	96	90
9750751	China, People's Republic Of	3535	2019	1551	1765	115	58
9750763	China, People's Republic Of	3535	2019	1492	1765	115	58
9730529	China, People's Republic Of	3544	2019	1400	2099	115	58
9728291	China, People's Republic Of	2366	2015	212	455	115	143
9728306	China, People's Republic Of	2366	2015	273	516	115	143
9744192	China, People's Republic Of	2914	2015	212	365	115	143
9898319	China, People's Republic Of	2379	2021	670	1035	11	22
9898321	China, People's Republic Of	2379	2022	762	1127	11	26
9898333	China, People's Republic Of	2379	2022	882	1247	11	26
9898345	China, People's Republic Of	2379	2022	913	1278	11	26

9898357	China, People's Republic Of	2216	2021	670	1035	11	22
9898369	China, People's Republic Of	2216	2022	762	1127	11	26
9898371	China, People's Republic Of	2216	2022	882	1247	11	26
9898383	China, People's Republic Of	2216	2022	943	1308	11	26
9898412	China, People's Republic Of	2370	2020	336	731	11	25
9898424	China, People's Republic Of	2570	2020	366	700	3	25
9898436	China, People's Republic Of	2370	2021	428	823	11	22
9898448	China, People's Republic Of	2370	2021	428	823	11	22
9517161	China, People's Republic Of	1219	2008	458	640	145	90
9520156	China, People's Republic Of	1219	2008	488	670	145	90
9520168	China, People's Republic Of	1219	2008	488	549	142	90
9548718	China, People's Republic Of	1788	2009	366	762	145	111
9672337	China, People's Republic Of	2955	2013	181	547	148	154
9672349	China, People's Republic Of	2955	2013	181	578	148	154
9699464	China, People's Republic Of	2955	2014	212	424	173	160
9699476	China, People's Republic Of	2955	2014	304	516	173	160
9745134	China, People's Republic Of	2915	2015	304	455	115	143

9745146	China, People's Republic Of	2915	2015	365	516	115	143
9745158	China, People's Republic Of	2915	2015	426	577	115	143
9745160	China, People's Republic Of	2915	2015	457	608	115	143
9747625	China, People's Republic Of	4548	2015	395	515	115	143
9747637	China, People's Republic Of	4548	2015	457	577	115	143
9762247	China, People's Republic Of	2372	2015	365	426	173	143
9692595	China, People's Republic Of	3601	2018	1857	2069	173	97
9764893	China, People's Republic Of	2935	2017	1157	1277	115	99
9602796	China, People's Republic Of	2575	2011	487	638	76	86
9602801	China, People's Republic Of	2575	2011	548	699	76	86
9721475	China, People's Republic Of	2948	2016	639	943	173	118
9764879	China, People's Republic Of	2932	2016	700	1124	173	118
9775567	China, People's Republic Of	2948	2018	943	1127	15	66
9533672	China, People's Republic Of	3601	2012	244	1552	89	90
9599028	China, People's Republic Of	2226	2011	669	850	58	94
9602813	China, People's Republic Of	2226	2011	700	1003	89	94
9533579	China, People's Republic Of	3601	2011	242	1277	89	86

9307463	China, People's Republic Of	2321	2005	456	669	45	50
9307451	China, People's Republic Of	2321	2005	335	731	45	50
9615494	China, People's Republic Of	1292	2011	455	789	58	94
9319040	China, People's Republic Of	1637	2005	334	670	60	50
9752838	China, People's Republic Of	3434	2017	761	1035	115	76
9752840	China, People's Republic Of	3434	2017	915	1219	115	76
9581150	China, People's Republic Of	1517	2010	304	608	58	101
9561239	China, People's Republic Of	2418	2009	487	731	89	111
9622112	China, People's Republic Of	1093	2012	213	486	185	90
9777747	China, People's Republic Of	1580	2015	335	426	115	143
9777759	China, People's Republic Of	1580	2015	365	821	173	143
9777709	China, People's Republic Of	1580	2016	214	275	15	95
9777761	China, People's Republic Of	1580	2016	244	335	15	95
9777773	China, People's Republic Of	1580	2016	336	427	15	95
9652193	China, People's Republic Of	3601	2014	334	1034	185	160
9739202	China, People's Republic Of	3804	2022	2952	3044	115	59
9664237	China, People's Republic Of	2908	2013	335	517	148	127

9697052	China, People's Republic Of	3927	2014	518	669	173	160
9752979	China, People's Republic Of	4125	2022	2313	2922	115	46
9761530	China, People's Republic Of	3677	2020	2069	2100	115	68
9761580	China, People's Republic Of	3677	2022	2557	3195	173	46
9761566	China, People's Republic Of	3677	2022	2831	2892	115	59
9682291	China, People's Republic Of	3123	2015	276	792	148	143
9747285	China, People's Republic Of	3658	2016	244	670	115	95
9729441	China, People's Republic Of	3449	2022	2802	3257	173	46
9698692	China, People's Republic Of	3288	2020	2435	2496	173	79
9787417	China, People's Republic Of	3567	2017	976	1096	115	99
9630121	China, People's Republic Of	1764	2014	671	945	185	140
9533660	China, People's Republic Of	3601	2012	396	1461	89	90
9734886	China, People's Republic Of	4367	2016	639	882	115	118
9694036	China, People's Republic Of	3467	2022	2649	3197	173	59
9539626	China, People's Republic Of	2369	2009	244	700	89	110
9307475	China, People's Republic Of	2324	2005	365	669	45	50
9277163	China, People's Republic Of	1369	2002	395	669	54	28

9562647	China, People's Republic Of	3891	2010	791	1035	89	104
9680877	China, People's Republic Of	3583	2014	518	669	148	160
9277175	China, People's Republic Of	1369	2002	244	365	56	38
9720689	China, People's Republic Of	1964	2018	1492	1857	173	86
9643374	China, People's Republic Of	3404	2012	396	487	76	90
9643386	China, People's Republic Of	3404	2012	487	578	76	90
9647007	China, People's Republic Of	3231	2014	426	792	185	140
9693903	China, People's Republic Of	3214	2014	669	1369	185	140
9693898	China, People's Republic Of	3214	2014	577	1277	185	140
9690250	China, People's Republic Of	2309	2014	273	577	148	160
9482469	China, People's Republic Of	2369	2008	244	731	145	111
9482457	China, People's Republic Of	2369	2008	244	578	145	90
9747182	China, People's Republic Of	4956	2018	1127	1372	115	66
9319038	China, People's Republic Of	1637	2005	365	517	60	50
9715000	China, People's Republic Of	3542	2014	457	547	148	160
9668245	China, People's Republic Of	3708	2013	184	366	148	127
9563794	China, People's Republic Of	2369	2010	212	546	58	101

9654153	China, People's Republic Of	3601	2012	244	457	185	100
9533610	China, People's Republic Of	3601	2012	275	1796	89	100
9697076	China, People's Republic Of	3927	2015	426	850	173	143
9721463	China, People's Republic Of	2948	2015	609	821	173	143
9576181	China, People's Republic Of	1840	2010	426	1157	142	101
9394399	China, People's Republic Of	1517	2008	274	912	96	90
9444041	China, People's Republic Of	1060	2008	578	943	145	90
9579004	China, People's Republic Of	1053	2010	395	852	89	101
9625217	China, People's Republic Of	1120	2011	456	1064	58	86
9662241	China, People's Republic Of	1615	2013	458	580	185	111
9803194	China, People's Republic Of	1193	2016	731	761	115	118
9707558	China, People's Republic Of	3924	2018	1096	1676	173	66
9713698	China, People's Republic Of	2962	2016	943	974	173	127
9394533	China, People's Republic Of	1517	2008	304	641	142	111
9689251	China, People's Republic Of	5077	2017	731	1492	173	76
9645683	China, People's Republic Of	4003	2013	397	703	185	127
9656644	China, People's Republic Of	4007	2014	396	976	185	140

9656620	China, People's Republic Of	4007	2013	457	884	185	127
9656632	China, People's Republic Of	4007	2014	426	976	185	140
9656656	China, People's Republic Of	4007	2014	396	1066	185	160
9656668	China, People's Republic Of	4007	2014	396	1127	185	160
9656670	China, People's Republic Of	4007	2014	426	1277	185	160
9656682	China, People's Republic Of	4007	2014	427	1339	185	160
9656694	China, People's Republic Of	4007	2014	426	1369	185	160
9579200	China, People's Republic Of	2921	2010	395	577	58	101
9561227	China, People's Republic Of	2418	2009	334	456	89	111
9471939	China, People's Republic Of	2443	2007	365	821	96	64
9761401	China, People's Republic Of	2173	2018	1124	1247	115	66
9761437	China, People's Republic Of	2173	2020	1705	2070	115	52
9779446	China, People's Republic Of	4657	2019	1127	1341	15	58
9570931	China, People's Republic Of	2921	2010	396	731	89	104
9761425	China, People's Republic Of	2173	2018	1126	1369	115	66
9686948	China, People's Republic Of	4335	2014	486	547	148	140
9661819	China, People's Republic Of	3555	2012	609	700	76	90

9547415	China, People's Republic Of	3140	2011	1399	1552	142	98
9787429	China, People's Republic Of	3972	2016	884	976	115	118
9676929	China, People's Republic Of	3370	2015	610	914	148	147
9652181	China, People's Republic Of	3601	2014	395	1034	185	160
9274410	China, People's Republic Of	3406	2005	884	1249	56	52
9386677	China, People's Republic Of	4602	2007	365	699	145	64
9787405	China, People's Republic Of	3995	2015	549	669	115	143
9697088	China, People's Republic Of	3927	2015	303	911	173	143
9366665	China, People's Republic Of	3665	2009	790	1308	96	97
9756511	China, People's Republic Of	2888	2015	304	365	115	143
9761413	China, People's Republic Of	2173	2016	516	639	115	95
9648623	China, People's Republic Of	2644	2013	395	700	185	127
9770189	China, People's Republic Of	3795	2018	1155	1308	115	66
9648635	China, People's Republic Of	2644	2013	456	761	185	127
9618082	China, People's Republic Of	2644	2013	578	912	185	111
9618070	China, People's Republic Of	2644	2013	487	821	185	111
9770177	China, People's Republic Of	4055	2018	1155	1308	115	66

9669990	China, People's Republic Of	3601	2014	395	730	148	160
9681364	China, People's Republic Of	3120	2014	273	607	148	160
9690262	China, People's Republic Of	2309	2014	273	608	148	160
9527594	China, People's Republic Of	2426	2009	428	672	142	97
9394090	China, People's Republic Of	2377	2008	458	853	145	90
9655482	China, People's Republic Of	3601	2013	456	700	148	127
9648283	China, People's Republic Of	2901	2012	244	700	185	100
9680621	China, People's Republic Of	2948	2013	183	456	148	154
9729465	China, People's Republic Of	2955	2022	3195	3438	148	69
9671369	China, People's Republic Of	2638	2022	2984	3684	148	69
9737929	China, People's Republic Of	3467	2022	2708	3073	173	59
9680633	China, People's Republic Of	2948	2022	3195	3529	148	69
9697179	China, People's Republic Of	2948	2022	3042	3407	173	59
9737931	China, People's Republic Of	3467	2022	2677	3073	173	46
9775579	China, People's Republic Of	2948	2022	2404	2649	15	46
9750139	China, People's Republic Of	3583	2022	2922	2922	115	59
9739460	China, People's Republic Of	3583	2022	3044	3136	115	59

9739472	China, People's Republic Of	3583	2022	3105	3197	115	59
9394363	China, People's Republic Of	1517	2008	366	851	96	90
9617791	China, People's Republic Of	2899	2012	244	670	76	90
9729439	China, People's Republic Of	3560	2022	2983	3287	173	59
9571260	China, People's Republic Of	1515	2010	334	485	58	101
9697090	China, People's Republic Of	3927	2016	487	1095	173	118
9653927	China, People's Republic Of	3147	2014	607	1126	185	160
9689263	China, People's Republic Of	5361	2018	1340	2101	173	66
9458327	China, People's Republic Of	2442	2008	366	913	96	90
9680889	China, People's Republic Of	3616	2017	1431	1643	148	110
9645695	China, People's Republic Of	4003	2013	395	792	185	127
9656723	China, People's Republic Of	4003	2013	426	609	185	127
9656735	China, People's Republic Of	4003	2013	426	701	185	127
9692612	China, People's Republic Of	4983	2019	2069	2250	173	87
9692624	China, People's Republic Of	4983	2020	2375	2556	173	79
9277046	China, People's Republic Of	1232	2002	427	639	54	28
9676931	China, People's Republic Of	3370	2019	2283	2587	148	87

9710933	China, People's Republic Of	4125	2019	1887	2161	173	76
9676943	China, People's Republic Of	3370	2020	2435	2800	148	79
9676955	China, People's Republic Of	3370	2020	2557	2922	148	79
9707285	China, People's Republic Of	3601	2015	518	730	173	147
9734032	China, People's Republic Of	4125	2019	1461	1795	115	58
9752967	China, People's Republic Of	4125	2020	1766	2284	115	52
9701528	China, People's Republic Of	3601	2015	549	610	173	147
9752955	China, People's Republic Of	4125	2019	1492	2040	115	58
9710945	China, People's Republic Of	4125	2019	1645	2041	173	76
9659385	China, People's Republic Of	3370	2018	1673	2191	148	97
9734020	China, People's Republic Of	4125	2019	1735	2038	115	76
9533696	China, People's Republic Of	3601	2012	578	1521	89	90
9533701	China, People's Republic Of	3601	2012	700	1643	89	90
9659373	China, People's Republic Of	3370	2018	1673	2191	148	97
9325594	China, People's Republic Of	1337	2004	336	640	45	49
9533555	China, People's Republic Of	3601	2011	365	1186	89	86
9671319	China, People's Republic Of	2638	2013	457	670	148	127

9671357	China, People's Republic Of	2638	2015	791	1400	148	147
9727900	China, People's Republic Of	3535	2019	1492	1857	173	76
9698458	China, People's Republic Of	3469	2014	365	516	173	160
9727912	China, People's Republic Of	3535	2019	1614	1857	173	76
9727895	China, People's Republic Of	3535	2016	670	882	173	118
9671345	China, People's Republic Of	2638	2014	669	1004	148	140
9654177	China, People's Republic Of	3601	2013	306	519	185	127
9533634	China, People's Republic Of	3601	2011	457	1369	89	86
9589865	China, People's Republic Of	1393	2011	242	881	58	86
9589841	China, People's Republic Of	1393	2010	214	365	76	92
9681376	China, People's Republic Of	2997	2014	243	577	148	160
9589877	China, People's Republic Of	1399	2011	334	973	58	86
9658159	China, People's Republic Of	3120	2013	184	670	148	154
9589889	China, People's Republic Of	1399	2011	243	942	58	86
9590151	China, People's Republic Of	1393	2010	304	335	76	92
9589853	China, People's Republic Of	1393	2010	214	365	76	92
9696802	China, People's Republic Of	4424	2014	334	334	173	160

9533658	China, People's Republic Of	3601	2011	274	1339	89	86
9369289	China, People's Republic Of	1271	2006	334	455	60	61
9653903	China, People's Republic Of	3147	2014	516	912	185	140
9690781	China, People's Republic Of	2929	2014	579	640	173	160
9539717	China, People's Republic Of	2428	2008	335	700	142	111
9704544	China, People's Republic Of	2955	2014	153	426	173	165
9679763	China, People's Republic Of	2955	2013	212	335	148	154
9698446	China, People's Republic Of	3469	2014	518	549	173	160
9729453	China, People's Republic Of	2955	2019	2222	2344	173	87
9668257	China, People's Republic Of	3602	2013	243	882	185	127
9659361	China, People's Republic Of	3370	2015	671	1067	148	147
9707560	China, People's Republic Of	3924	2019	1520	2100	173	58
9671395	China, People's Republic Of	2948	2013	304	457	148	127
9694115	China, People's Republic Of	2955	2014	153	457	148	160
9703045	China, People's Republic Of	2955	2014	426	548	173	160
9703033	China, People's Republic Of	2955	2014	153	487	173	165
9694127	China, People's Republic Of	2955	2014	153	457	148	160

9680657	China, People's Republic Of	2948	2013	245	670	148	154
9680669	China, People's Republic Of	2948	2014	273	790	148	160
9720706	China, People's Republic Of	2030	2022	2434	3134	173	46
9541239	China, People's Republic Of	2428	2009	397	519	142	111
9643362	China, People's Republic Of	2259	2012	701	823	76	90
9667227	China, People's Republic Of	3601	2013	426	700	148	127
9667239	China, People's Republic Of	3944	2013	426	700	148	127
9307700	China, People's Republic Of	2919	2005	365	517	45	50
9655494	China, People's Republic Of	3601	2014	487	731	148	140
9557654	China, People's Republic Of	3753	2010	730	1096	142	104
9756509	China, People's Republic Of	2888	2015	304	365	115	143
9680774	China, People's Republic Of	1686	2013	212	365	148	154
9754513	China, People's Republic Of	2973	2017	1157	1157	115	99
9753222	China, People's Republic Of	1770	2015	365	487	115	143
9533646	China, People's Republic Of	3689	2012	580	1492	89	90
9720718	China, People's Republic Of	2030	2022	2435	3226	173	46
9685750	China, People's Republic Of	3638	2015	396	761	173	143

9685762	China, People's Republic Of	3638	2015	487	942	173	143
9709128	China, People's Republic Of	3638	2016	549	852	173	118
9709130	China, People's Republic Of	3638	2016	639	1065	173	118
9742089	China, People's Republic Of	3638	2017	822	1187	115	76
9742091	China, People's Republic Of	3638	2018	1004	1430	115	66
9689201	China, People's Republic Of	3548	2015	396	883	173	143
9689213	China, People's Republic Of	3548	2015	457	944	173	143
9697521	China, People's Republic Of	3548	2016	517	1035	173	118
9720732	China, People's Republic Of	3548	2016	456	913	173	95
9720744	China, People's Republic Of	3548	2016	397	974	173	95
9664213	China, People's Republic Of	2937	2013	273	486	148	127
9664225	China, People's Republic Of	2937	2013	212	517	148	127
9680803	China, People's Republic Of	2946	2014	396	639	148	160
9555278	China, People's Republic Of	2308	2009	303	669	142	111
9686950	China, People's Republic Of	4343	2014	424	516	148	160
9728019	China, People's Republic Of	3535	2021	2588	2831	173	62
9754525	China, People's Republic Of	2948	2019	1703	1915	115	76

9332274	China, People's Republic Of	1095	2005	365	487	60	50
9550400	China, People's Republic Of	1060	2010	396	579	89	104
9634048	China, People's Republic Of	1214	2011	395	699	76	86
9653654	China, People's Republic Of	1284	2012	397	458	185	90
9653666	China, People's Republic Of	1284	2012	366	458	185	90
9553505	China, People's Republic Of	1517	2009	273	884	142	111
9730531	China, People's Republic Of	2995	2019	1400	2099	115	58
9767596	China, People's Republic Of	2955	2020	2344	2436	173	79
9754537	China, People's Republic Of	2948	2020	1978	2039	115	68
9331294	China, People's Republic Of	2321	2006	365	821	60	61
9421790	India	2177	2010	762	1341	145	96
9576375	India	1831	2014	1492	1612	58	118
9394296	India	1973	2008	640	731	145	76
9576404	India	1831	2016	2192	2312	58	111
9499307	India	2176	2010	974	1096	142	104
9444364	India	2177	2010	638	1310	142	101
9394301	India	2082	2009	973	1126	145	82
9344227	India	1969	2008	1188	1400	96	72
9413195	India	3582	2010	882	1308	145	96
9483059	India	5103	2014	2191	2373	142	116
9264013	India	1218	2003	396	671	54	37
9667198	India	3205	2014	457	882	148	160
9667203	India	3205	2014	549	1035	148	160
9703758	India	3530	2015	515	760	173	143
9483047	India	4863	2012	1492	1674	142	98
9350496	India	2160	2007	457	699	96	63
9576349	India	1831	2012	976	1096	58	90
9576363	India	1831	2013	1280	1400	58	106
9413183	India	3402	2009	670	973	145	97

9511844	India	2177	2010	699	1035	142	104
9350501	India	2160	2007	365	789	96	64
9350525	India	2160	2007	273	972	96	69
9576387	India	1831	2014	1645	1765	58	118
9575620	India	3455	2013	425	1520	58	127
9575632	India	3455	2014	731	1826	58	140
9624744	India	3455	2014	549	1492	76	140
9624756	India	3455	2014	761	1704	76	140
9421805	India	2319	2009	486	943	145	111
9421776	India	2177	2009	548	1066	145	97
9421764	India	2177	2009	517	1035	145	97
9576351	India	1831	2013	1068	1188	58	106
9576399	India	1831	2015	1887	2007	58	119
9499319	India	2176	2012	1338	1613	142	98
9192997	India	1433	2000	792	1247	26	32
9529920	India	4059	2011	487	1187	89	86
9529932	India	4059	2012	394	1339	89	90
9392975	India	2160	2008	153	1065	145	111
8318453	India	5455	1988	1614	2588	21	10
9575606	India	2633	2012	335	1308	58	90
9575618	India	2633	2012	427	1400	58	90
9387190	India	2160	2008	275	730	145	90
9392963	India	2160	2008	153	943	145	111
9350513	India	2160	2007	334	880	96	64
9421788	India	2177	2009	731	1279	145	97
9413482	India	1615	2009	1006	1249	145	97
9480734	India	4508	2012	549	1553	142	90
9444352	India	2177	2010	577	1218	142	104
9480722	India	4059	2011	365	1369	142	86
9511856	India	2177	2010	515	1126	142	101
9443657	India	2917	2013	1280	2192	142	107
9443645	India	2917	2012	1522	1947	142	98
9466099	India	2917	2013	1492	2192	142	107
9344215	India	1969	2007	638	850	96	63
9444338	India	2177	2010	638	1157	142	104
9444340	India	2177	2010	335	1188	142	101
9725213	Netherlands	2107	2015	395	577	173	143
9725225	Netherlands	2107	2015	365	730	173	143
9725172	Netherlands	2107	2016	334	761	173	95
9725237	Netherlands	2107	2016	366	852	173	95
9725184	Netherlands	2107	2016	335	882	173	95
9725249	Netherlands	2107	2016	305	913	173	95
9725196	Netherlands	2107	2016	305	974	173	95
9725251	Netherlands	2107	2016	366	1035	173	95
9725201	Netherlands	2107	2016	396	1096	173	95
9725263	Netherlands	2107	2017	458	1158	173	76

7392957	Netherlands	1274	1974	153	1005	16	21
7381635	Netherlands	1310	1974	151	1066	16	21
7404217	Netherlands	1188	1975	92	549	37	22
9329435	Netherlands	3739	2005	274	396	60	50
9394258	Netherlands	4290	2007	427	518	145	64
9549205	Netherlands	2085	2011	1095	1430	89	98
9435545	Netherlands	1649	2008	214	396	145	90
9276468	Netherlands	1209	2002	92	243	56	38
9455284	Netherlands	1868	2008	243	547	142	90
7406813	Netherlands	1165	1975	212	426	37	22
9549217	Netherlands	2085	2012	1187	1492	89	98
9690872	Netherlands	1856	2014	212	457	173	160
9715282	Netherlands	1961	2014	668	699	173	160
9549231	Netherlands	2085	2011	1004	1339	89	98
9549229	Netherlands	2085	2011	942	1277	89	98
7404176	Netherlands	1177	1975	243	457	37	22
7432111	Netherlands	1369	1976	336	1341	24	23
7406825	Netherlands	1513	1975	183	640	37	22
9549188	Netherlands	1502	2009	334	639	89	111
7336654	Netherlands	1104	1974	245	1037	16	12
9738636	Netherlands	1847	2015	1217	1492	185	124
7502966	Netherlands	1829	1977	306	1341	24	28
7606308	Netherlands	1803	1977	212	1188	37	28
7424762	Norway	1202	1974	334	1218	16	12
8401432	Norway	1823	1984	244	366	8	16
8111001	Norway	2169	1983	393	1430	98	64
9429467	Norway	2415	2009	365	821	145	111
8520771	Norway	2592	1987	334	1461	23	10
9343766	Norway	3337	2006	337	427	60	61
8112665	Norway	2099	1983	245	1311	98	64
9201059	Norway	1969	1999	273	577	13	38
8107153	Norway	2649	1982	303	1157	98	63
9495284	Norway	2479	2011	212	303	76	86
9418690	Norway	2241	2008	488	639	145	90
9411680	Norway	2239	2007	275	518	145	69
9397274	Norway	2332	2007	303	515	145	64
8406999	Norway	2562	1985	517	1126	12	13
9369540	Norway	2082	2006	334	487	96	61
8912340	Norway	2637	1990	303	334	9	6
9244568	Norway	4030	2002	273	547	13	28
9640231	Norway	2214	2012	151	304	185	100
9344332	Norway	2192	2006	276	427	60	61
9663025	Norway	2418	2013	212	365	148	127
9043067	Norway	1823	1992	183	274	5	7
8211863	Norway	2891	1983	273	1064	58	64
9246114	Norway	5886	2002	549	1005	13	28

9613707	Norway	3644	2012	366	640	76	90
9613692	Norway	3644	2012	275	396	76	90
9649562	Norway	4258	2012	335	396	185	90
8112691	Norway	1339	1982	303	1004	98	63
9288253	Norway	3743	2003	214	303	45	57
8912338	Norway	2637	1990	212	486	9	6
8110992	Norway	2528	1983	337	1402	98	64
9133111	Norway	3041	1996	213	366	46	7
9399155	Norway	2239	2007	304	548	145	64
9165906	Norway	1971	1998	304	455	17	26
9086215	Norway	2961	1995	212	516	7	5
9538531	Norway	3062	2010	243	304	58	101
9665011	Norway	4926	2014	486	669	148	140
9034793	Norway	6380	1993	276	672	5	4
9034779	Norway	6380	1992	275	519	5	7
9244609	Norway	3078	2002	153	427	13	28
7727384	Norway	2904	1979	518	1308	33	33
9165970	Norway	1968	1997	212	578	26	10
9255098	Norway	1970	2001	275	914	19	17
9350238	Norway	2466	2005	243	640	60	60
9210921	Norway	2186	1999	304	1247	46	38
8119637	Norway	2597	1983	212	669	21	64
9591882	Norway	4258	2011	396	608	76	86
9683659	Norway	4560	2013	273	395	148	127
9627772	Norway	5335	2013	397	641	185	111
9591870	Norway	4258	2011	273	516	76	86
9422108	Norway	8414	2010	427	1188	145	104
9742766	Norway	4508	2017	884	1006	115	99
9654098	Norway	4513	2014	518	731	148	140
9643465	Norway	4513	2013	456	639	185	127
9294006	Norway	2542	2003	183	365	45	57
8127012	Norway	1223	1983	457	1187	58	64
9128350	Norway	2998	1996	456	821	11	7
8506854	Norway	2306	1986	426	1340	23	11
9418705	Norway	3131	2008	305	548	145	90
9221176	Norway	1972	2000	275	609	19	30
8112524	Norway	1924	1982	303	1157	98	63
8112536	Norway	1833	1982	365	1066	98	63
9731250	Norway	4609	2015	365	516	115	143
9668647	Norway	5400	2014	457	853	148	160
9034767	Norway	2961	1992	274	427	5	7
9087312	Norway	3056	1994	212	212	7	3
9239599	Norway	2165	2001	212	365	13	17
9163025	Norway	2126	1997	273	1065	11	10
9188128	Norway	3040	1999	184	337	13	38
9424508	Norway	4869	2009	548	882	142	97

9408994	Norway	4869	2009	519	915	145	97
9383871	Norway	4859	2008	579	730	145	76
9741279	Norway	3649	2019	1887	1979	115	76
9489493	Norway	3117	2009	334	700	142	111
9538529	Norway	3129	2010	304	546	89	101
9385300	Norway	5372	2007	335	577	145	64
9201047	Norway	1969	1999	304	1186	46	38
9267039	Norway	2150	2003	245	306	56	48
9236157	Norway	2152	2001	242	273	13	19
9000637	Norway	2789	1991	396	486	9	8
9596296	Norway	5381	2012	335	790	76	90
9611840	Norway	5381	2012	336	670	76	90
9106431	Norway	3052	1995	245	275	11	5
9722510	Norway	3636	2015	334	426	173	143
9359208	Norway	2579	2006	335	365	96	61
9362009	Norway	3922	2006	273	457	96	61
9362011	Norway	3922	2007	365	580	96	64
9325829	Norway	3790	2005	245	428	60	50
9741554	Norway	2419	2015	365	426	115	143
9365104	Norway	2579	2006	303	334	96	61
9741542	Norway	2420	2014	273	304	115	165
9350240	Norway	2466	2005	275	731	60	60
9393424	Norway	2193	2008	517	882	145	90
9382944	Norway	4309	2008	457	730	145	76
9455832	Norway	3062	2009	669	945	142	111
9263631	Norway	3396	2003	396	427	54	48
9409297	Norway	2193	2009	365	1004	145	111
9374193	Norway	2160	2006	273	396	96	61
9385518	Norway	2160	2007	273	454	145	64
9722522	Norway	4197	2015	306	426	173	143
9331268	Norway	4978	2005	365	425	60	50
9732216	Norway	4903	2016	761	851	115	118
9339428	Norway	4667	2005	242	334	60	60
9330977	Norway	2154	2005	273	365	60	50
9667253	Norway	4800	2014	334	761	148	160
9644342	Norway	4552	2013	519	519	185	111
9620982	Norway	4344	2012	458	762	76	90
9667241	Norway	4800	2014	395	669	148	160
9390604	Norway	5275	2008	548	851	145	76
9690066	Norway	4768	2014	457	610	173	160
9263083	Norway	3343	2002	243	274	54	38
9544516	Norway	4344	2011	426	669	76	86
9372901	Norway	6111	2008	549	853	96	76
9257606	Norway	2417	2003	365	761	54	48
9316440	Norway	2451	2005	426	487	60	50
9418664	Norway	2871	2009	639	1035	145	97

9430753	Norway	2933	2009	670	1096	145	111
9390551	Norway	2871	2009	703	1068	145	97
9334533	Norway	2465	2005	242	670	60	60
9645932	Norway	3963	2013	456	639	185	127
9750593	Netherlands	6053	2017	703	946	115	76
9750581	Netherlands	6053	2017	580	915	115	76
9750610	Netherlands	6053	2017	731	974	115	76
9322188	Norway	2152	2005	306	335	60	50
9648025	Netherlands	3832	2013	365	609	185	127
9748344	Norway	3515	2016	609	731	115	118
9747493	Norway	3515	2016	578	670	115	118
9638123	Netherlands	3832	2013	396	701	185	127
9395408	Norway	2180	2008	394	731	145	90
9367011	Norway	2652	2007	304	577	96	64
9333864	Norway	2265	2005	243	487	60	50
9448528	Norway	4488	2009	548	975	142	111
9623025	Norway	3580	2012	335	488	185	90
9608740	Norway	3943	2013	608	1369	76	127
9262857	Norway	2161	2003	547	851	54	37
9390666	Norway	2304	2007	304	579	145	69
9402342	Norway	2304	2008	427	792	145	90
9465136	Norway	3639	2010	457	1158	142	101
9319985	Norway	4200	2005	242	395	60	50
9608738	Norway	3943	2013	456	1186	76	127
9334129	Norway	2077	2005	274	335	60	50
9409845	Norway	2180	2008	335	945	145	111
9402330	Norway	2304	2008	427	700	145	90
9385104	Norway	2304	2007	426	638	145	64
9395458	Norway	2180	2008	366	884	145	90
9249403	Norway	2244	2002	334	1037	19	28
9297797	Norway	2151	2004	275	761	56	49
9355991	Norway	2615	2007	273	1003	60	64
9448530	Norway	6029	2010	486	1066	142	104
9392834	Norway	2179	2008	366	884	145	90
9392846	Norway	2179	2008	336	945	145	90
9340532	Norway	2263	2005	245	365	60	60
9395422	Norway	2180	2008	427	792	145	90
9384461	Norway	2615	2007	304	607	145	64
9249465	Norway	2244	2003	393	730	54	48
9364021	Norway	3702	2007	365	639	96	64
9439450	Norway	3639	2009	457	976	142	111
9645956	Norway	3362	2014	426	823	185	140
9371696	Norway	4382	2007	488	700	96	64
9366598	Norway	4382	2007	365	608	96	64
9419761	Norway	4608	2009	365	1035	145	111
9722871	Norway	5068	2015	424	486	173	143

9695042	Norway	5068	2014	457	549	173	160
9602526	Norway	4676	2012	489	762	76	90
9602514	Norway	4676	2012	486	670	76	90
9759903	Norway	4764	2018	1278	1339	115	86
9390549	Norway	4277	2008	427	761	145	90
9239343	Norway	2244	2001	334	1034	13	19
9395434	Norway	2180	2008	336	884	145	90
9177844	Norway	3388	1999	577	820	17	30
9409857	Norway	2180	2009	365	974	145	111
9249623	Norway	1992	2002	365	365	54	28
9653123	Netherlands	3832	2015	1004	1217	185	135
9608271	Norway	3943	2013	488	1096	76	111
9249427	Norway	2137	2002	395	426	54	28
9249415	Norway	2137	2002	334	365	54	28
9333503	Norway	2152	2006	335	638	60	61
9714159	Netherlands	3042	2015	426	669	173	143
9714147	Netherlands	3042	2015	365	488	173	143
9645968	Norway	3315	2014	485	974	185	160
9333515	Norway	2152	2006	335	730	60	61
9395446	Norway	2180	2009	337	1007	145	111
9280902	Norway	2152	2003	395	456	56	48
9592812	Norway	5280	2012	457	610	76	90
9249489	Norway	5402	2002	396	549	54	28
9616187	Norway	3527	2012	457	608	76	90
9388950	Norway	4755	2008	517	762	145	76
9381691	Norway	4755	2008	580	761	145	76
9408229	Norway	5211	2009	486	943	145	97
9591856	Norway	4590	2011	365	638	76	86
9616175	Norway	5370	2012	519	700	76	90
9629005	Norway	3527	2013	488	731	185	111
9665786	Norway	4797	2014	456	760	148	160
9591868	Norway	4590	2012	427	761	76	90
9364033	Norway	3702	2007	335	639	96	64
9439462	Norway	3639	2010	457	1068	142	104
9243370	Norway	3557	2003	426	761	13	37
9285536	Norway	2161	2004	366	425	45	49
9249453	Norway	1992	2003	426	822	54	48
9603829	Norway	5197	2012	517	608	76	90
9650200	Norway	3832	2013	426	731	185	127
9269491	Norway	2137	2002	303	730	13	38
9750608	Netherlands	6422	2017	580	915	115	76
9378034	Norway	2534	2008	578	851	96	76
9285524	Norway	2161	2004	275	365	45	49
9366835	Norway	2596	2006	365	638	60	61
9482354	Norway	4518	2011	516	1247	142	94
9482342	Norway	4518	2011	487	1188	142	94

9482366	Norway	4518	2011	547	1308	142	94
9482330	Norway	4518	2010	427	1066	142	101
9239604	Norway	2168	2001	273	426	13	17
9334545	Norway	2576	2006	275	457	60	61
9158678	Norway	3016	1998	487	791	26	26
9645944	Norway	3315	2013	457	731	185	127
9335678	Norway	4992	2006	365	516	60	61
9335680	Norway	4992	2006	365	638	60	61
9335692	Norway	4992	2006	365	730	60	61
9194103	Norway	3104	1999	273	608	13	38
9370070	Norway	4601	2007	518	913	96	64
9625425	Norway	3966	2012	427	547	185	90
9330680	Norway	3350	2005	303	334	60	50
9284324	Norway	2592	2004	394	456	56	49
9607693	Norway	3959	2011	365	669	76	86
9372896	Norway	4469	2009	519	1219	96	97
9508067	Norway	5054	2011	427	1158	89	94
9613824	Norway	3958	2012	425	487	76	90
9625009	Norway	3788	2012	366	549	185	90
9312119	Norway	2152	2004	213	517	45	49
9741281	Norway	3649	2021	2496	2618	115	62
9276391	Norway	3482	2003	426	761	54	37
9339492	Norway	2167	2005	212	640	60	60
9363778	Norway	4201	2007	334	699	96	64
9363728	Norway	4183	2007	365	639	96	64
9695937	Norway	5938	2015	457	610	173	147
9351969	Norway	3357	2006	334	454	96	61
9584554	Norway	4323	2011	426	607	76	86
9258430	Norway	5073	2003	396	577	54	48
9590565	Norway	4283	2012	488	761	76	90
9328546	Norway	3331	2005	273	396	60	50
9355953	Norway	2465	2006	304	518	96	61
9273208	Norway	2401	2003	396	608	56	48
9334131	Norway	2168	2005	212	243	60	50
9194294	Norway	3465	1999	396	1492	46	38
9694000	Norway	4969	2014	457	640	148	140
9649184	Norway	3409	2013	548	882	185	111
9628386	Norway	4201	2012	305	486	185	90
9303481	Norway	2151	2004	244	335	45	49
9355989	Norway	2465	2006	303	426	96	61
9306914	Norway	6545	2004	457	519	45	49
9378046	Norway	2534	2008	670	1035	96	76
9280914	Norway	2154	2003	243	608	56	48
9648166	Netherlands	3832	2013	426	670	185	127
9664445	Netherlands	3832	2013	365	579	148	127
9647758	Norway	2793	2013	334	486	185	127

9462770	Norway	4366	2010	1249	1310	142	96
9451422	Norway	2814	2009	548	823	142	97
9631890	Norway	4424	2012	366	549	185	90
9479967	Norway	3022	2011	457	1249	142	94
9667760	Norway	4075	2013	396	517	148	127
9664380	Norway	2793	2013	304	457	148	127
9534353	Norway	2814	2010	549	702	89	104
9690949	Norway	4324	2014	365	549	173	160
9740732	Norway	5999	2021	2648	2801	115	62
9634347	Norway	4552	2013	550	642	185	111
9653989	Norway	3361	2012	305	488	185	90
9535292	Norway	3260	2011	365	1308	89	86
9475181	Norway	5106	2011	1400	1430	142	92
9510307	Norway	5106	2010	882	1155	142	96
9591923	Norway	4000	2012	486	790	76	90
9644445	Norway	3309	2012	336	517	185	90
9422213	Norway	4366	2009	550	854	145	97
9439022	Norway	4366	2009	579	973	142	111
9409675	Norway	6111	2009	640	943	145	97
9434503	Norway	2661	2008	549	669	142	90
9651890	Norway	3644	2013	273	547	185	127
9665126	Norway	3636	2013	274	457	148	127
9665102	Norway	3639	2013	273	334	148	127
9665114	Norway	3636	2013	273	365	148	127
9653111	Netherlands	3832	2014	669	852	185	140
9250749	Norway	3252	2002	396	1127	19	28
9263514	Norway	3360	2002	365	1005	19	28
9395410	Norway	2180	2008	488	853	145	90
9521655	Norway	4176	2011	546	1034	89	94
9521667	Norway	4176	2011	607	1095	89	94
9281657	Norway	3285	2003	488	700	56	48
9417359	Norway	3131	2009	822	1522	96	97
9372224	United States Of America	1659	2005	1035	1400	56	52
9383792	United States Of America	1201	2007	700	942	96	63
9184524	United States Of America	1083	1997	365	731	26	10
9679438	United States Of America	3563	2014	730	821	148	140
9626508	United States Of America	1234	2011	1126	1308	89	98

9347358	United States Of America	2994	2006	273	393	96	61
9530058	United States Of America	4524	2012	699	1675	142	90
9264520	United States Of America	2068	2002	518	669	54	28
9288655	United States Of America	3045	2003	549	730	54	48
9257333	United States Of America	1129	2003	275	518	54	48
9085845	United States Of America	1978	1993	212	1188	6	3
9515840	United States Of America	2998	2008	366	517	142	90
9472373	United States Of America	2428	2009	334	1096	145	111
9219903	United States Of America	1893	1999	273	1614	46	39
9207613	United States Of America	1942	2000	276	365	19	30
9730311	United States Of America	4828	2014	426	699	173	160
9700988	United States Of America	1158	2013	549	609	148	127
9203837	United States Of America	1395	1998	488	1066	46	26
9264506	United States Of America	2068	2002	334	516	54	28
9285287	United States Of America	2045	2005	335	762	56	50
9670080	United States Of America	1158	2012	519	639	185	90
9724271	United States Of America	1170	2015	457	547	173	143

9472347	United States Of America	2428	2009	427	762	145	97
9652208	United States Of America	3563	2014	762	945	185	125
9529695	United States Of America	2998	2009	334	823	142	111
9721114	United States Of America	4856	2014	395	454	173	160
9670640	United States Of America	2378	2015	1065	1187	148	135
9645645	United States Of America	3378	2014	638	1218	185	140
9684835	United States Of America	3641	2014	488	974	148	160
9704295	United States Of America	3849	2015	608	820	173	147
8301072	United States Of America	1189	1983	212	850	21	64
9296183	United States Of America	1888	2003	243	547	56	48
9763746	United States Of America	5768	2021	2800	2922	173	72
9206827	United States Of America	1327	1998	304	1066	46	37
9518957	United States Of America	5289	2011	973	1095	89	98
9211080	United States Of America	1327	1999	547	1217	46	30
9213002	United States Of America	1335	1999	577	1278	46	30
9226279	United States Of America	1327	2000	761	1187	26	32
9208447	United States Of America	1200	1999	334	1186	46	38

7417159	United States Of America	1022	1975	303	303	37	22
9744623	United States Of America	1427	2015	486	761	173	147
9421386	United States Of America	2183	2007	457	608	145	64
9421374	United States Of America	2183	2007	457	516	145	64
9292319	United States Of America	1598	2003	485	912	54	48
9744611	United States Of America	1426	2014	518	610	173	160
9296353	United States Of America	1598	2003	518	639	56	48
9205108	United States Of America	1395	1998	548	730	26	26
9724283	United States Of America	1170	2015	487	669	173	143
9030321	United States Of America	1124	1991	335	730	9	9
9752357	United States Of America	4828	2015	577	669	173	147
9232723	United States Of America	1335	2000	792	1096	17	32
9230830	United States Of America	1327	2000	762	1247	26	32
9132155	United States Of America	2042	1996	884	914	11	5
9205122	United States Of America	1891	1998	273	730	26	26
9132296	United States Of America	2141	1998	580	793	26	19
9132284	United States Of America	2106	1998	516	1704	7	19

9132301	United States Of America	2140	1997	1249	1553	7	8
9132167	United States Of America	2043	1997	1217	5388	12	8
9191228	United States Of America	1961	1998	365	821	46	26
8943301	United States Of America	2140	1998	334	730	26	26
9132260	United States Of America	1699	1998	549	1645	7	19
9203215	United States Of America	2092	1998	396	974	46	26
9382865	United States Of America	2996	2007	365	608	96	64
9203825	United States Of America	2092	1998	335	1066	46	26
9207821	United States Of America	2092	1999	396	1158	46	38
9670391	United States Of America	3242	2013	334	578	148	127
9219484	United States Of America	2092	1999	518	1278	26	38
9226293	United States Of America	2092	2000	518	1187	26	32
9423114	United States Of America	3086	2008	305	790	145	90
9670327	United States Of America	3242	2013	335	517	148	127
9285263	United States Of America	2045	2004	335	670	56	49
9320166	United States Of America	1058	2004	335	670	45	49
9447407	United States Of America	1751	2010	547	821	89	104

9503445	United States Of America	1751	2010	518	943	89	101
9271705	United States Of America	2282	2002	365	577	54	28
9347334	United States Of America	3075	2005	365	670	60	50
9418547	United States Of America	2435	2011	730	2099	145	94
9421398	United States Of America	2183	2008	426	761	96	76
9719733	United States Of America	3242	2014	518	762	148	140
9670389	United States Of America	3242	2013	337	397	148	127
9273569	United States Of America	3135	2003	215	427	56	48
9315496	United States Of America	3045	2004	274	759	56	49
9320415	United States Of America	3045	2004	851	1278	54	45
9132234	United States Of America	1891	1997	1126	1308	11	8
9670626	United States Of America	2393	2013	823	853	185	111
9285299	United States Of America	1708	2005	334	821	56	50
9529669	United States Of America	2998	2009	366	580	142	111
9226267	United States Of America	2092	2000	731	1216	26	32
9245940	United States Of America	2295	2000	61	730	13	30
9220249	United States Of America	2092	2000	671	1156	26	32

9213014	United States Of America	2092	1999	487	1308	46	38
9220251	United States Of America	2092	1999	396	1095	26	38
9212993	United States Of America	2092	1999	426	1278	46	38
9218026	United States Of America	2092	1999	396	1370	46	38
9196565	United States Of America	2092	1998	304	913	46	26
9275012	United States Of America	3183	2002	515	577	54	28
9347346	United States Of America	2994	2006	427	762	60	56
9257357	United States Of America	1189	2006	1551	1673	54	48
9763734	United States Of America	4649	2016	883	975	173	127
9132258	United States Of America	2876	1997	1188	1370	11	8
9788356	United States Of America	4829	2019	1918	1948	173	87
9410856	United States Of America	1708	2008	609	700	145	76
9273430	United States Of America	1624	2004	579	610	56	45
9347322	United States Of America	2994	2005	365	395	60	50
9309306	United States Of America	1888	2004	334	396	45	49
9529889	United States Of America	2998	2009	183	884	142	110
9234551	United States Of America	1489	2000	701	1308	26	32

9472361	United States Of America	2428	2009	365	1004	145	111
9198496	United States Of America	1099	1998	395	730	17	26
9724295	United States Of America	1158	2015	488	488	173	147
9677935	United States Of America	4757	2016	1004	1400	148	127
9285330	United States Of America	2045	2005	334	974	56	50
9690004	United States Of America	1445	2013	457	578	148	127
9788344	United States Of America	4539	2017	1338	1399	173	110
9670353	United States Of America	3242	2012	336	427	185	90
9515852	United States Of America	2998	2008	366	578	142	90
9704283	United States Of America	3400	2014	579	638	173	160
9564310	United States Of America	2287	2009	457	670	89	111
9514547	United States Of America	1111	2008	639	943	145	76
8980701	United States Of America	1101	2003	396	700	56	48
9297747	United States Of America	1101	2003	365	577	56	48
7517727	United States Of America	1210	1978	212	1216	30	31
9703746	United States Of America	4828	2014	546	577	148	160
9481374	United States Of America	4150	2009	1066	1127	145	82

9703693	United States Of America	4880	2014	487	577	173	160
9688477	United States Of America	4458	2018	1946	2251	148	98
9743057	United States Of America	8417	2017	1369	1583	173	110
9603295	United States Of America	1158	2010	549	1066	142	101
9388120	United States Of America	2287	2010	485	1612	145	101
9780835	United States Of America	1424	2015	730	760	173	147
9581289	United States Of America	3912	2012	547	943	76	90
9678197	United States Of America	1158	2013	489	762	185	111
9582300	United States Of America	3498	2014	1369	1581	76	118
9617703	United States Of America	1158	2011	608	820	58	94
9581291	United States Of America	4645	2013	700	1277	76	111
9388144	United States Of America	1870	2006	454	485	96	61
9579901	United States Of America	1842	2010	912	1308	142	104
9654220	United States Of America	4458	2015	1096	1219	185	135
9270127	United States Of America	1749	2003	607	791	54	37
9551052	United States Of America	1654	2009	642	762	142	97
9654256	United States Of America	4458	2017	1612	1886	148	108

9752515	United States Of America	1158	2014	579	638	173	160
9582295	United States Of America	3498	2013	1035	1247	76	106
9591650	United States Of America	1158	2010	457	974	89	101
9787314	United States Of America	2920	2017	672	703	15	76
9536246	United States Of America	1596	2009	395	914	142	111
9581277	United States Of America	4381	2012	517	821	76	90
9559951	United States Of America	1786	2010	274	761	89	101
9559963	United States Of America	1812	2011	973	1339	89	98
9654244	United States Of America	4458	2016	1369	1551	148	122
9559949	United States Of America	1786	2010	547	669	89	104
9654232	United States Of America	4458	2015	1248	1461	185	135
9270115	United States Of America	1739	2003	518	792	54	37
9536210	United States Of America	1914	2009	395	761	142	111
9587702	United States Of America	1158	2010	516	882	142	104
9563225	United States Of America	1839	2009	700	853	142	97
9577874	United States Of America	1659	2010	884	884	142	96
9536222	United States Of America	1596	2009	427	823	142	111

9665334	United States Of America	1158	2012	519	578	185	90
9536234	United States Of America	1596	2009	395	853	142	111
9388118	United States Of America	2261	2007	518	608	145	64
9581227	United States Of America	3912	2011	244	699	76	79
9536208	United States Of America	1596	2009	426	731	142	111
7517715	United States Of America	1210	1977	153	1369	37	33
9273545	United States Of America	1235	2006	1369	1400	56	53
9677923	United States Of America	4092	2016	1096	1308	148	127
9195523	United States Of America	1099	1998	183	1096	46	37
9564322	United States Of America	2287	2010	455	790	89	104
9382358	United States Of America	1691	2008	427	882	145	90
9752333	United States Of America	4828	2014	488	549	173	160
9647681	United States Of America	4885	2014	608	882	185	140
9240184	United States Of America	1809	2000	1126	1218	17	28
9647693	United States Of America	4217	2014	577	943	185	140
9647708	United States Of America	4219	2014	638	1004	185	140
9647710	United States Of America	4217	2014	699	1065	185	140

9273480	United States Of America	1863	2003	273	455	56	48
9229922	United States Of America	1809	2000	943	1035	17	28
9216377	United States Of America	1809	1999	487	1126	26	38
9672636	United States Of America	4630	2015	1095	1156	148	135
9672648	United States Of America	5089	2015	1034	1095	148	135
9271016	United States Of America	2520	2002	335	516	54	28
9587398	United States Of America	3764	2011	700	820	58	94
9647629	United States Of America	3835	2014	760	1126	185	140
9647590	United States Of America	3835	2014	730	973	185	140
9647576	United States Of America	3835	2014	671	792	185	140
9672600	United States Of America	3835	2015	820	942	148	147
9207182	United States Of America	1809	1999	487	1096	26	30
9672595	United States Of America	3835	2015	1003	1125	148	147
9040546	United States Of America	5960	1992	486	1277	4	7
9224934	United States Of America	1809	2000	852	1156	26	28
9647588	United States Of America	3835	2014	638	851	185	140
9647605	United States Of America	3835	2014	668	973	185	140

9686156	United States Of America	2971	2015	639	820	173	147
9647564	United States Of America	3835	2013	610	731	185	127
9518622	United States Of America	3387	2009	609	790	142	97
9227065	United States Of America	1549	2000	580	1553	46	32
9647631	United States Of America	3835	2015	791	1157	185	135
9647617	United States Of America	3835	2014	761	1096	185	140
9203459	United States Of America	1226	1998	700	1096	46	26
9207601	United States Of America	1226	1999	181	304	13	38
9265811	United States Of America	1999	2002	276	1341	13	28
9529877	United States Of America	2998	2009	488	823	142	111
9270995	United States Of America	1863	2003	304	547	56	48
9271004	United States Of America	1863	2003	274	639	56	48
9251808	United States Of America	1815	2001	274	821	19	19
9472440	United States Of America	1863	2009	245	762	145	111
9385257	United States Of America	2996	2006	395	607	96	61
9472323	United States Of America	2391	2008	610	792	145	90
9236884	United States Of America	1489	2000	1065	1157	17	28

9472438	United States Of America	1863	2008	305	701	145	111
9472385	United States Of America	1955	2010	365	1158	145	101
9472414	United States Of America	1863	2008	335	517	145	90
9647643	United States Of America	3911	2013	548	578	185	111
9647655	United States Of America	3911	2013	608	700	185	127
9686144	United States Of America	2971	2014	609	699	173	160
9647667	United States Of America	3911	2013	549	731	185	127
9472335	United States Of America	1997	2008	458	670	145	90
9647679	United States Of America	5721	2014	549	792	185	140
9645619	United States Of America	3446	2013	670	914	185	111
9645621	United States Of America	3446	2014	671	1006	185	140
9385269	United States Of America	2996	2007	396	730	96	64
9645633	United States Of America	3446	2014	639	1096	185	140
9246865	United States Of America	2520	2002	487	607	54	28
9495533	United States Of America	1863	2009	334	578	89	111
9273478	United States Of America	1863	2004	306	426	56	49
9495545	United States Of America	1934	2009	304	670	89	110

9385271	United States Of America	2998	2008	518	730	145	76
9211937	United States Of America	1318	1999	304	1277	46	38
9472402	United States Of America	1955	2010	273	1339	145	101
9490064	United States Of America	3764	2010	669	791	89	104
9472397	United States Of America	1955	2010	304	1308	145	101
9285275	United States Of America	2045	2004	305	701	56	40
9263887	United States Of America	1560	2002	883	1066	19	25
9202845	United States Of America	1238	1998	395	669	17	26
9215220	United States Of America	1931	1999	365	1400	46	38
9530008	United States Of America	3242	2012	457	1857	142	90
9175004	United States Of America	1074	1997	1096	1308	11	8
9564308	United States Of America	2287	2009	518	793	142	111
7807665	United States Of America	1361	1978	153	1430	30	29
9529891	United States Of America	3482	2010	212	974	142	101
9273454	United States Of America	1624	2004	610	641	56	45
9551636	United States Of America	3336	2010	577	1096	142	104
9670365	United States Of America	3242	2013	304	425	148	127

9207170	United States Of America	1893	1999	214	1341	46	38
7819668	United States Of America	1155	1979	182	1247	33	33
9009322	United States Of America	1105	1991	577	730	9	8
9199373	United States Of America	1171	1998	365	1065	46	26
9202766	United States Of America	1104	1998	426	1126	46	26
9418092	United States Of America	1153	2007	396	730	96	63
9328376	United States Of America	3045	2004	884	1066	56	45
9207900	United States Of America	1099	1999	426	1339	46	38
9191515	United States Of America	1095	1998	151	852	46	26
9383780	United States Of America	1659	2007	789	789	96	63
9206683	United States Of America	1226	1999	245	1157	46	38
9418535	United States Of America	2326	2010	821	1520	145	96
9690389	United States Of America	3641	2015	456	852	173	143
9273428	United States Of America	1624	2003	548	730	56	48
9732486	United States Of America	2499	2019	1765	2250	173	76
9530034	United States Of America	2998	2010	456	1126	142	101
9418511	United States Of America	1313	2008	486	790	145	76

9009334	United States Of America	1124	1991	669	1369	4	8
7644207	United States Of America	1031	1976	182	1246	24	23
9215074	United States Of America	2012	1999	365	1338	46	38
9800386	United States Of America	4828	2018	1553	1706	173	97
9382877	United States Of America	2994	2006	365	515	96	61
9273533	United States Of America	1235	2004	579	730	56	45
9273521	United States Of America	1235	2003	395	546	56	48
9257345	United States Of America	1417	2003	577	638	54	37
9732498	United States Of America	2499	2021	2282	2981	173	62
9191096	United States Of America	1099	1998	273	1004	46	26
9261803	United States Of America	3183	2002	488	793	19	25
9668166	United States Of America	4156	2013	731	1065	185	111
9164483	United States Of America	1074	1997	1066	1278	11	8
9132208	United States Of America	2043	1997	1157	1339	11	8
9529671	United States Of America	2998	2009	425	670	142	111
9529657	United States Of America	2998	2008	489	519	142	90
9704269	United States Of America	3920	2014	485	485	173	160

9382281	United States Of America	1691	2008	457	761	145	76
9382334	United States Of America	1691	2008	396	851	145	90
9382841	United States Of America	3575	2007	335	547	96	64
9207596	United States Of America	1226	1999	181	455	13	38
9517795	United States Of America	3336	2009	397	823	145	111
9272060	United States Of America	4488	2003	516	699	54	37
9203227	United States Of America	2262	1998	457	1218	46	26
9221841	United States Of America	1549	1999	335	1461	46	38
9281396	United States Of America	3183	2002	488	700	54	28
9264635	United States Of America	1854	2002	456	699	54	28
9213040	United States Of America	1342	1999	730	1278	46	30
9558555	United States Of America	1111	2009	913	1278	145	82
9302279	United States Of America	2698	2005	914	1096	45	52
9668154	United States Of America	4156	2013	700	1004	185	111
9204570	United States Of America	1342	1998	548	1096	46	26
9302267	United States Of America	2698	2005	731	913	45	52
9399064	United States Of America	1201	2008	731	1277	96	76

9399595	United States Of America	1227	2008	640	640	145	76
9315501	United States Of America	2045	2004	366	882	56	49
9257369	United States Of America	1237	2004	671	914	54	45
9529683	United States Of America	2998	2009	334	792	142	111
9752369	United States Of America	4828	2018	1584	1737	173	97
9397729	United States Of America	1235	2006	426	577	96	61
9289661	United States Of America	1888	2003	457	792	54	37
9730323	United States Of America	4828	2015	547	820	173	147
9744166	United States Of America	4649	2016	914	975	173	127
9137040	United States Of America	1409	1995	516	1064	2	5
9551507	United States Of America	3336	2010	668	1096	142	104
9283057	United States Of America	1670	2003	303	730	56	57
9582312	United States Of America	2918	2014	852	1551	76	125
9693525	United States Of America	4298	2017	1249	1371	173	110
9009346	United States Of America	1160	1991	730	791	9	8
9298985	United States Of America	1784	2004	579	761	56	45
9734977	United States Of America	1158	2014	485	485	173	160

9582324	United States Of America	2918	2015	791	1826	76	135
9704271	United States Of America	3117	2015	518	730	173	147
7417173	United States Of America	1022	1975	365	1126	11	22
9530010	United States Of America	3242	2012	366	1857	142	90
9732474	United States Of America	2499	2016	730	1095	173	118
9529994	United States Of America	3242	2012	519	1888	142	90
7932226	United States Of America	1195	1980	336	1645	33	37
9481506	United States Of America	5371	2009	518	792	142	111
9315525	United States Of America	2045	2004	335	974	56	49
9670339	United States Of America	3242	2013	304	609	148	127
9530022	United States Of America	3242	2012	397	1919	142	90
9232436	United States Of America	1054	2000	578	1004	17	30
9752345	United States Of America	4828	2015	516	669	173	147
9183001	United States Of America	1183	1997	1127	1614	7	8
9203071	United States Of America	1099	1999	214	1430	46	38
9753519	United States Of America	1424	2015	610	699	173	147
9498676	United States Of America	1111	2008	457	730	145	76

9724300	United States Of America	1424	2015	639	700	173	147
9458793	United States Of America	1111	2007	640	730	96	64
9742338	United States Of America	1445	2014	577	760	148	140
9720897	United States Of America	1445	2014	608	669	148	140
9823601	United States Of America	1634	2017	943	1065	115	76
9883596	United States Of America	1634	2020	1553	1675	15	52
9801964	United States Of America	1634	2016	578	700	115	118
9283564	United States Of America	1243	2004	487	761	56	45
9706176	United States Of America	1445	2013	548	700	148	127
9903097	United States Of America	1634	2021	1856	1948	15	35
9807528	United States Of America	1634	2016	792	822	115	118
9849306	United States Of America	1634	2019	1311	1492	15	58
9670638	United States Of America	2312	2014	669	791	148	140
9744154	United States Of America	4828	2014	518	669	173	160
9653862	United States Of America	1158	2012	396	486	185	90
9779214	United States Of America	4379	2016	761	883	173	127
9690391	United States Of America	3641	2016	427	1067	173	118

9802425	United States Of America	4379	2016	852	943	173	127
9559975	United States Of America	2225	2011	1095	1461	89	98
9717711	United States Of America	3010	2015	1217	1400	185	124
9201645	United States Of America	2217	1998	426	1249	46	26
9225495	United States Of America	2227	2000	334	1706	46	30
9214915	United States Of America	2252	1999	487	1095	26	38
7819682	United States Of America	1039	1979	153	730	37	36
7932238	United States Of America	1530	1981	365	1887	33	42
9670315	United States Of America	3242	2013	427	488	185	111
9684847	United States Of America	3641	2015	577	1124	148	147
9730309	United States Of America	5011	2014	424	455	173	160
9187215	United States Of America	1099	1998	184	854	46	26
9577678	United States Of America	3365	2013	1277	1612	58	107
9354038	United States Of America	5565	2007	822	973	96	63
9579925	United States Of America	1656	2010	882	1278	142	104
9222637	United States Of America	1124	1999	334	730	17	39
9645657	United States Of America	3518	2015	699	1371	185	147

9212424	United States Of America	1395	1999	638	1247	46	30
9472359	United States Of America	2428	2009	334	821	145	111
9717307	United States Of America	1158	2014	518	518	148	140
9763758	United States Of America	4592	2015	608	730	173	147
9693537	United States Of America	4298	2018	1795	1917	173	97

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