



# **The Lay-Up Decision in Practice**

*How offshore supply shipowners respond to lower demand*

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**NORWEGIAN SCHOOL OF ECONOMICS**

This thesis was written as a part of the Master of Science in Economics and Business Administration at NHH. Please note that neither the institution nor the examiners are responsible – through the approval of this thesis – for the theories and methods used, or results and conclusions drawn in this work.

## Abstract

The purpose of this thesis is to improve the understanding of how offshore supply shipowners adapt to lower demand by putting ships in lay-up. We have examined how day rates affect lay-up levels, and sought to explain other factors than day rates that might impact the lay-up decision. We have also looked at how specific vessel characteristics impact the likelihood that a given vessel will be laid up.

We have used both a qualitative and an empirical approach in our research. In the qualitative part, we have interviewed seven Norwegian offshore supply shipowners that operate Platform Supply Vessels (PSV) and/or Anchor Handling Tug Supply (AHTS) vessels in the North Sea. We have found that in addition to using lay-up to reduce costs, the shipowners see the opportunity to reduce supply as a main motivation for laying up vessels. They achieve this by coordinating lay-up levels and thus engage in tacit collusion.

Furthermore, we have found that the attractiveness of lay-up depends on the market outlook, the opportunity to scrap or sell vessels, startup costs for new vessels, vessel deterioration when in lay-up, and the ability to keep employees and competence in the company.

The qualitative part of our research enabled us to formulate some hypotheses that we tested empirically using fleet statistics and day rates from the North Sea region. Using OLS, we found that day rates are negatively correlated with lay-up levels, but that there might be a time lag in how a reduction in day rates leads to an increase in laid up vessels.

Using logistic regression, we found that vessel age had some negative correlation with lay-up levels, though the correlation was not strong. High capacity as measured by clear deck area for PSVs had a significant, negative correlation with the likelihood of lay-up. Bollard pull had a significant, negative correlation with the likelihood of lay-up for AHTSs.

## Preface

This thesis is written as a part of our Master of Science in Economics and Business Administration within our major in Business Analysis and Performance Management.

Over the last two years, the downturn in the oil industry has been a widely discussed topic nationally and internationally. Lower offshore activity has led to a large increase in the amount of laid up offshore supply vessels in Norway. This has triggered our curiosity to how the lay-up decision is made. The downturn has given us an opportunity to explore and quantify how shipowners use lay-up as a response to lower demand.

Early on in our research we were told by an industry professional that data in the offshore sector is often incorrect, incomplete or may not present the full story. Getting access to data has been one of the major challenges in writing this thesis, and we are very grateful to the two shipbrokers who provided us with the data that enabled us to perform the empirical part of the analysis.

We are also very thankful to the shipowners who have taken the time to participate in our interviews. Without their willingness to share information, we would not have been able to write this thesis.

We would like to thank our supervisor, Chiara Canta, for her insights and guidance throughout the semester. Her feedback and perspectives have been highly valued, and challenged us to improve the quality of our work in ways we would not have thought of ourselves.

Bergen, June 15<sup>th</sup> 2016

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# 1. Introduction

Lower oil price and reduced offshore activity has led to lower day rates in the offshore supply shipping industry in the period from 2014 to 2016. Faced with lower demand, shipowners are looking for options to reduce supply. One of the responses has been to put ships in lay-up. By taking ships out of operation, shipowners are able to reduce costs and limit the loss from offshore supply activities. By the end of 2015 over 100 Norwegian owned offshore vessels were in lay-up (Norwegian Shipowner's Association, 2016). The oil price drop and reduced offshore activity gives a valuable opportunity to study the lay-up decision in practice.

We have found the existing literature on the lay-up decision to be limited. Most of the literature on offshore supply shipping concerns routing problems and treats the vessels as if they were homogenous. With this thesis we want to make a contribution to supply the existing literature on the option to lay-up a ship with new research, by focusing on the shipowner's lay-up decision in practice.

We have analyzed how day rates affect lay-up levels in the offshore supply industry. We have also investigated which other factors than day rates that can have an impact on the shipowners' lay-up decision. Additionally, we have analyzed how the shipowners evaluate which ships to lay up. The analysis was performed by using both a qualitative and an empirical research approach.

## 1.1 Research questions

We have formulated our research questions as:

- i. How does day rates affect lay-up levels?
- ii. Which other factors than day rates have an impact on the lay-up decision?
- iii. How does shipowners determine which vessels to lay up?

## 1.2 Findings

In the qualitative part of our research, we interviewed seven Norwegian shipowners who operate Platform Supply Vessels (PSVs) and/or Anchor Handling Tug Supply (AHTS)

vessels in the North Sea. The interviews were used to gain an understanding of how shipowners evaluate the lay-up decision both in terms of when to lay up a part of the fleet, and which vessels to lay up.

We found that in addition to using lay-up to reduce costs, shipowners are also motivated by the opportunity to reduce supply. This is because a reduction of supply will increase the rates earned by the remaining operational fleet. Because the offshore supply industry is fragmented with many small players, each shipowner has a limited ability to impact overall supply. But by using signaling and expectations between the shipowners, they are able to coordinate their efforts to reduce supply. This is a form of tacit collusion that is not illegal, but allows the shipowners to exert supplier power in a way that they would not be able to achieve individually.

We also found that there are several other factors that affect the lay-up decision of a shipowner. There seems to be a pessimistic market outlook, which leads to quicker and longer lay-up. Sales prices in the second hand market for offshore supply vessels are low, and the scrapping potential is limited because the fleet is relatively modern. This makes lay-up a more favorable alternative. The startup costs associated with bringing a new ship to market means that putting a newbuild directly in lay-up could be more advantageous than introducing it to the market. Vessels deteriorate while in lay-up, and because it may take time to get a ship operational again, customers might be reluctant to award a new contract to a vessel that is in lay-up. Anticipating this, shipowners might be more reluctant to put ships in lay-up in the first place.

Based on the qualitative part of our research and the available academic literature, we formulated three hypotheses that we tested empirically using fleet statistics and day rates for the North Sea region. The hypotheses are:

- Hypothesis 1: Day rates can be used to predict lay-up levels
- Hypothesis 2: Higher volatility in day rates leads to lower lay-up levels
- Hypothesis 3: The following characteristics will make a vessel less likely to be laid up
  - Low age
  - High capacity

Hypotheses 1 and 2 were tested using Ordinary Least Squares (OLS). We found that day rates and lay-up levels are negatively correlated, but that there might be a time lag in how a change in day rates affects the lay-up levels. We were not able to show that higher volatility leads to lower lay-up levels.

Hypothesis 3 was tested using logistic regression (logit). We found that low age seems to reduce the likelihood of lay-up, though the correlation was not strong. For PSVs, capacity as measured by clear deck area had a significant, negative correlation with the likelihood of lay-up. High pulling power as measured by bollard pull had a significant, negative correlation with the likelihood of lay-up for AHTSs.

### 1.3 The structure of the thesis

This thesis has five main sections. In section 2 we give an overview of the offshore supply shipping industry. In section 3 we present a review of the relevant academic literature on the topic. In section 4 we elaborate on the methodology, and in section 5 we present our analysis. Lastly, in section 6 we draw conclusions from our findings.

## 2. Industry overview

We will now present an overview of the offshore supply shipping industry. First we will explain some basic industry terms. Second we will look at how offshore supply vessels fit into the maritime industry. Third we will look at the market structure, including supply and demand drivers. Lastly we will look at the development in the market since the oil price drop in 2014 and how it has affected the shipowners.

### 2.1 Industry terms

**Charter agreement:** Agreement between a shipowner and a customer that hires a vessel for a period of time (see time charter) or a specific voyage (Stopford, 2009). Supply vessels are usually chartered by oil companies. The owner runs the day-to-day operation of the vessel, while the charterer directs the operations (Aas, Halskau Sr., & Wallace, 2009). A new charter agreement is called a fixture.

**Day rate:** The daily fee charged by the owner to charter a vessel on a time charter (Aas et al., 2009).

**Lay-up:** When a ship is temporarily taken out of service because rates are too low to cover operating and maintenance costs (Stopford, 2009).

**Spot contract:** Short term charter agreement that usually only lasts for the duration of a specific task (Aas et al., 2009). In the offshore segment, a contract is classified as a spot contract if the duration is less than 30 days.

**Term contract:** Long term charter agreement (Aas et al., 2009). The duration can be between 30 days and several years.

**Time charter:** Charter agreement where the charter hire is a fixed daily payment (the day rate). The owner pays the operating and capital costs. The charterer pays voyage related costs such as fuel and port charges (Stopford, 2009). This is the commonly used charter type in offshore supply shipping.

**Utilization:** The fraction of the fleet in a location that is currently on hire.

## 2.2 Context and delimitation

### 2.2.1 The Norwegian maritime industry

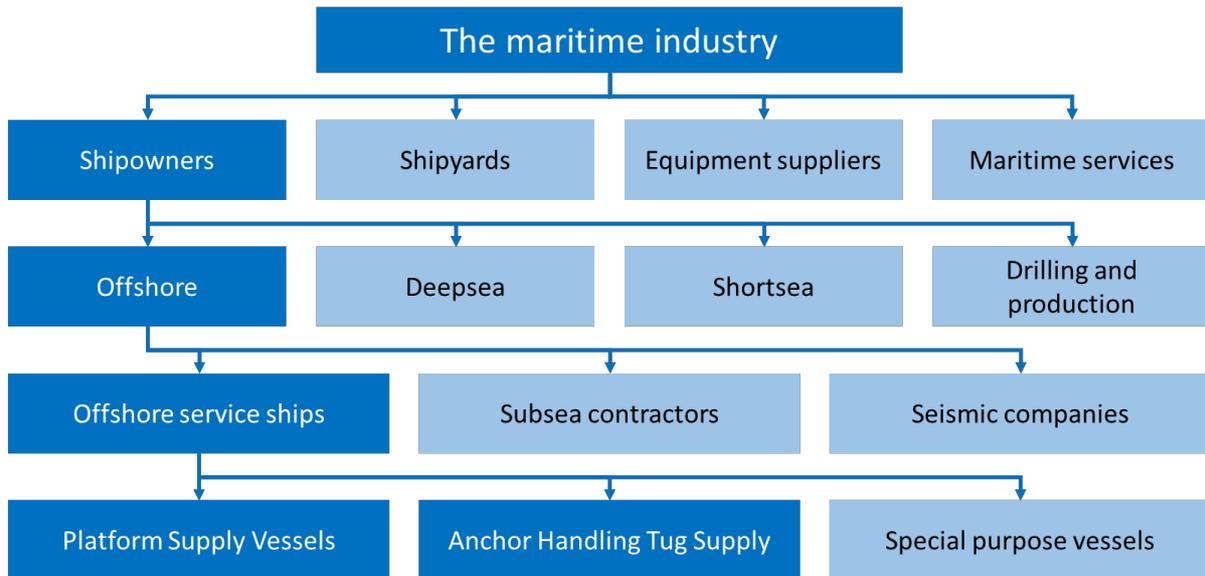
The *maritime industry* is defined as all enterprises that own, operate, design, build, and supply equipment or specialized services to all types of ships and other floating vessels (Menon Business Economics, 2015). The industry is one of Norway's largest. The annual value creation (EBITDA plus payroll expenses) in 2014 was NOK 190 billion, making up 12 percent of the national aggregate. The industry employs 110,000 workers in Norway alone (Norwegian Shipowner's Association, 2016).

Norway has a complete maritime cluster, which is rare globally. The cluster includes shipping companies, shipyards, equipment manufacturers, classification societies, ship designers, brokers, and insurance and financial services. The Norwegian shipping fleet is the world's sixth largest ranked by value as measured by construction costs (Norwegian Shipowner's Association, 2016).

Menon Business Economics (2015) classifies *shipowners* as one of four subgroups of the maritime industry, the other three being shipyards, equipment suppliers and maritime services. Shipowners are defined as owners and operators of ships and other floating vessels such as rigs and floating production equipment.

### 2.2.2 The offshore service segment

*Offshore shipowners* are classified by Menon Business Economics (2015) as a subgroup of shipowners that contribute to maintaining operation at offshore installations. Offshore shipowners can further be divided into three groups: Offshore service ships, subsea contractors and seismic companies. The *offshore service ship* segment consists of Platform Supply Vessels (PSV), Anchor Handling Tug Supply (AHTS) vessels and special purpose vessels (Menon Business Economics, 2015). PSVs and AHTSs are the topic for this thesis. We will refer to them collectively as "offshore supply vessels", and we will refer to owners of these vessels as "shipowners". An overview of how PSVs and AHTSs fit into Menon Business Economic's (2015) breakdown of the maritime industry is depicted in figure 2.1. More details on vessel types will be provided in section 2.2.3.



*Figure 2.1: An overview of Platform Supply Vessels and Anchor Handling Tug Supply vessels fit into Menon Business Economic's (2015) breakdown of the maritime industry*

Offshore service is the segment that makes the biggest contribution to the market value of the Norwegian shipping fleet. Measured by building cost adjusted for fleet age and size, the offshore service fleet was valued at over USD 26 billion, while the total fleet was valued at USD 72 billion in 2015. It is by far the segment that has experienced the largest growth the last decade, from a fleet value of less than USD 7 billion in 2005. This makes Norway's offshore service fleet the world's second most valuable, only surpassed by the US. A big contributor to the high market value of the fleet is that it is the world's most modern and technologically advanced (Norwegian Shipowner's Association, 2016).

The global fleet of offshore support vessels (here including deepwater PSVs, deepwater AHTSs and towing-supply vessels) amounted to 3,270 vessels at the end of March 2015. At the time, 540 new-builds were under construction or planned for delivery. An estimated 10 percent of the global fleet was laid up at the time (Tidewater, 2015).

### **2.2.3 Vessel types**

#### *Platform Supply Vessels (PSVs)*

Platform Supply Vessels (PSVs) are designed to supply offshore drilling and production facilities with cargo and personnel. The cargo shipped to platforms typically consists of production equipment, drilling equipment, chemicals, and supplies such as fuel, drinking

water and food. When returning to shore, PSVs carry drilling mud from well excavation, empty load carriers and excess equipment. The directional balance is usually good, meaning that the carrying capacity required to and from installations are fairly equally distributed. Most offshore installations require supplies frequently because of limited storage capacity and high day rates for rented drilling equipment (Norwegian Shipowner's Association, 2014; Aas et al., 2009).

In contrast to most types of ships used for transportation, PSVs are multipurpose vessels. The cargo can consist of deck cargo, which is placed on the ship's deck, and bulk cargo, which is placed in tanks below the deck. In addition, PSVs can perform other tasks such as emergency preparedness, including firefighting and oil-spill cleanup (Aas et al., 2009).

Demand for PSVs can fluctuate on short notice. Each installation typically has a fixed schedule where a PSV will visit the platform 2 to 3 times a week. But because of unexpected events on platforms, particularly drilling platforms, it can be difficult to follow the fixed schedule, and peaks in demand can occur (Aas, Gribkovskaia, Halskau Sr, & Shlopak, 2007).

### ***Anchor Handling Tug Supply (AHTS)***

Anchor Handling Tug Supply (AHTS or anchor handler) vessels set anchors for drilling rigs, and tow rigs and equipment to new locations. They can also be used to bring supplies to offshore installations, but generally have smaller carrying capacity than PSVs. AHTSs have winches for towing and anchor handling operations on board. Visually, they can be recognized by their open sterns that allow for anchors to be raised onboard. Some variations of the vessel type cannot carry supplies (AHT), and some can only tow (Norwegian Shipowner's Association, 2014).

Hiring anchor handlers is expensive, and anchor handling may constitute 10 to 20 percent of the total well exploitation cost for an oil company. Because these operations are technically complex, and because misjudgment can lead to project delay and significant economic losses, they require more skills and higher competence among the crew than PSVs (Wu, Gunnu, & Moan, 2015).

## 2.3 Market structure

### 2.3.1 The upstream oil and gas value chain

Upstream logistics in the oil and gas (O&G) industry are activities related to providing offshore drilling and production units with the necessary supplies (Aas et al., 2009).

The auditing and advisory firm Ernst & Young (2016) maps out the O&G value chain as illustrated in figure 2.2. The *reservoir/seismic* segment includes companies that operate seismic vessels, analyze and display seismic data, and supply equipment for such activities. The *exploration and production (E&P) drilling* segment includes companies that own or operate drilling rigs, and subcontractors for such companies. The *engineering, fabrication and installation* segment includes companies that supplies equipment to, manufactures and installs offshore O&G production units. The *operations* segment supports oil companies in the production phase, and includes offshore logistics, modification and maintenance services, and suppliers of production equipment and services. The *decommissioning* segment performs activities related to removing offshore installations (Ernst & Young, 2016).

In this value chain setup, offshore supply vessels are a part of the operations segment, specifically the sub-segment offshore logistics. In addition to offshore vessels, the segment also includes helicopter logistics and onshore supply bases (Ernst & Young, 2016).



Figure 2.2: Oil and gas value chain (Ernst & Young, 2016)

### 2.3.2 Demand drivers

Clarkson Capital Markets (2012) maps macro drivers of offshore supply vessel demand as illustrated in figure 2.3. The combination of energy demand and oil price is the fundamental driver of offshore supply vessel demand, through the intermediary variables E&P capital expenditures (CAPEX) and overall offshore activity (Clarkson Capital Markets, 2012). Because the fundamental driver works through these intermediary links, there can be a significant lag in time before changes in energy demand and oil price results in changes in offshore supply vessel demand.



*Figure 2.3: The combination of energy demand and oil prices is the fundamental driver for offshore supply vessel demand, and works through the intermediary links E&P CAPEX and offshore activity (Clarkson Capital Markets, 2012)*

### 2.3.3 Supply drivers

Long term, global supply in the offshore supply vessel market is driven by the balance between newbuilds and scrapped or repurposed vessels. Delivery of newbuilds increases supply, while scrapping and repurposing reduces supply. Vessels arriving to or departing from a region will respectively increase or decrease supply in a specific region, but will not impact global supply. Lay-up of vessels can reduce supply, but not permanently, because the laid up vessels can be reintroduced to the market.

### 2.3.4 Cyclicity

The shipping market has a market cycle with four different stages. During the *through* phase an overcapacity of ships drives down the rates earned by the shipowners towards operating costs. At this point shipowners sell or lay up their ships, and few or no newbuilds are ordered. During the *recovery* phase supply and demand reaches a balance at a lower level, which makes the rates rise above operating costs. At the *peak* the shipowners' liquidity increases as a consequence of the high rates, and new orders are placed for newbuilds. Eventually, the delivery of newbuilds leads to a *collapse* in the market where supply exceeds demand, and consequently the rates fall again (Scarsi, 2007).

In general, shipping cycles are related to the business cycle. Demand for shipping services is related to global economic activity, and when this activity unexpectedly grows or falls, it takes time for shipowners to adjust (Stopford, 2009). One of the main reasons for this is the time lag between ordering and delivery of a newbuild. Vessels that are ordered at the peak may take delivery in the through phase, which will worsen an already depressed market (Scarsi, 2007).

In offshore supply shipping, the shipping cycle is mainly driven by changes in energy demand and oil prices. Fluctuations in offshore activity is magnified through the supply chain because each level in the supply chain needs time to adjust to changes in demand. This is called the bullwhip effect, and leads to oscillation in prices, capital investment and utilization (Jacoby, 2012).

In other parts of the upstream O&G industry, suppliers have used vertical integration, scale and market dominance to avoid the large strain caused by the bullwhip effect (Jacoby, 2012). The offshore supply segment is however quite dispersed, with many smaller shipowners and the largest player Tidewater holding less than 10 percent of the global fleet. In addition, the shipowners are usually highly levered, which puts additional strain on a company when cash is limited. A high degree of operating costs are fixed, which means that lower activity levels have a big impact on profitability (Pareto Securities AS Equity Research, 2016).

## 2.4 Recent market development

### 2.4.1 Abrupt end to the high growth

Between the two oil price drops in 2008 and 2014, the Norwegian oilfield service industry was characterized by high demand and strong growth, and the trend in shipbuilding shifted toward larger and more high-end vessels. High growth in the rig fleet and more deepwater activity between 2010 and 2013 led to higher demand for offshore supply vessels and further increase in the newbuild orderbooks (Pareto Securities AS Equity Research, 2016).

A period of sharp decline in the oil price started in mid-2014, as can be seen from figure 2.4. The price per barrel went from USD 115 in June 2014 to just above USD 28 in January 2016 (Oslo Børs, 2016). The negative shock was partly caused by high supply stemming from a large influx of American shale oil, high production levels in Saudia Arabia and Russia, and lifted sanctions against Iran. In addition lower economic growth and instability led to lower demand (Norwegian Shipowner's Association, 2016).



*Figure 2.4: After a period of stable oil prices up until 2014, the price dropped from USD 115 per barrel in June 2014 to just above USD 28 in January 2016 (Federal Reserve Bank of St. Louis, 2016)*

The major oil companies announced reductions in future spending as early as the beginning of 2014. The drop in oil price during the course of 2014 led to even more substantial plans to cut spendings. Toward the end of 2014, the effect was noticeable for the supply segment. Lower activity among oil companies meant significant overcapacity of supply vessels. This led to a decline in utilization and lower day rates. Long term effects were a sharp decline in the newbuild orderbook and considerably lower margins for existing operations (Ernst & Young, 2016). Monthly average day rates are graphed in figure 2.5 for PSVs and figure 2.6 for AHTSs. For the AHTSs we see a sharp increase in day rates towards the end of 2015 and beginning of 2016. This recovery was caused by a reduction in supply as vessels were laid up (Dixon, 2015).



*Figure 2.5: Monthly average day rates for PSVs (Shipbroker2, see page 58)*

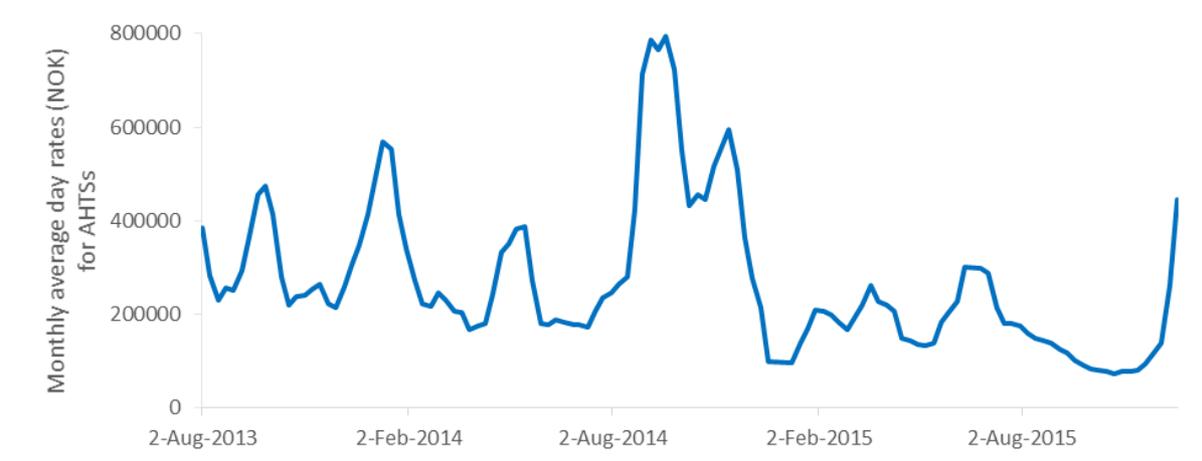


Figure 2.6: Monthly average day rates for AHTSs (Shipbroker2, see page 58)

Between fall 2014 and the end of 2015, the number of North Sea PSVs and AHTSs in lay-up went from 0 to around 100, as illustrated in figure 2.7. In shipowning companies overall, 7300 employees were laid off or terminated. 3150 of these were in the offshore service segment (Norwegian Shipowner's Association, 2016).

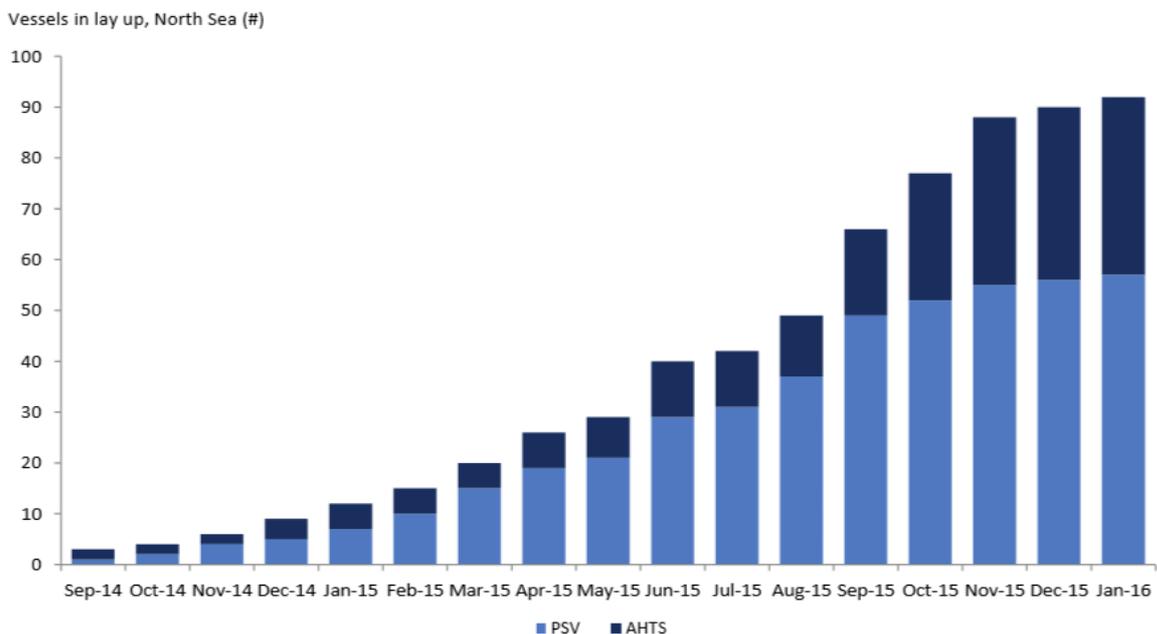


Figure 2.7: The number of PSVs and AHTSs in lay-up (Pareto Securities AS Equity Research, 2016)

## 2.4.2 Market imbalances

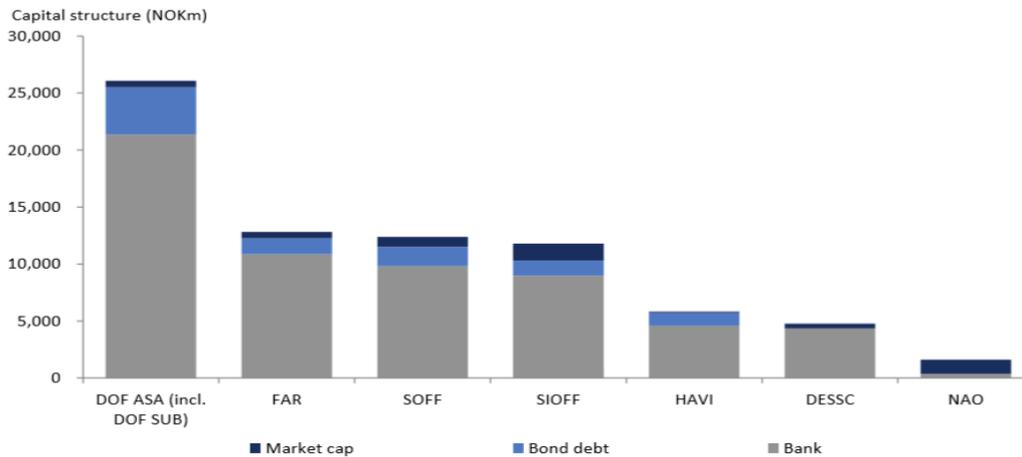
Shipowners have struggled to adapt to the lower demand. The lead time for an offshore supply newbuild is 12 to 24 months. Because of this lead time, many of the vessels that were

ordered in the peak season 2013/2014 were scheduled for delivery in 2015/2016. Global supply increased by 5 percent in 2015, and 149 AHTSs and 225 PSVs were under construction at year end, comprising 8 percent and 14 percent of the respective global fleets (Pareto Securities AS Equity Research, 2016; Ernst & Young, 2016).

The responses available to shipowners are cancelling newbuilds, scrapping or laying up parts of the operational fleet, and repurposing vessels to other sectors (Ernst & Young, 2016). Because the fleet in the North Sea is relatively modern, the scrapping potential is limited, and up until 2016 scrapping activity has been low. This leaves lay-up as a more relevant, though temporary, alternative to reduce supply (Fearnley Securities, 2015; Pareto Securities AS Equity Research, 2016).

### **2.4.3 Financial strain on shipowners**

A combination of highly levered companies and low operating income, has made the offshore supply shipowners particularly vulnerable to restructuring and takeovers. The capital structure of seven of the listed Norwegian offshore supply shipowners that operate in the North Sea is shown in figure 2.8. The rapid growth up until 2014 was largely financed by debt that will reach maturity over the next few years (Fearnley Securities, 2015; Pareto Securities AS Equity Research, 2016). Equity ratios will likely decrease as a result of further impairment of vessel values (Ernst & Young, 2016). Resale activity of vessels have so far been low, but cash constraints increases the number of forced sellers, which would put further strain on vessel values (Pareto Securities AS Equity Research, 2016).



*Figure 2.8: Capital structure for seven of the listed offshore supply shipowners that operate in the North Sea (Pareto Securities AS Equity Research, 2016)*

The shipowners' ability to refinance their debt is limited. In a survey conducted by the Norwegian Shipowner's Association (2016), two thirds of the surveyed shipowners in the offshore service segment described access to capital markets as tight or very tight.

Restructuring has already become necessary for the most cash constrained shipowners. World Wide Supply was taken over by its creditors in December 2015 after breaking the terms of its bond debt for several months. Havila Shipping, also after breaking debt terms, has been in comprehensive negotiations with banks and bond holders without being able to find a solution that all three parties are willing to agree on (Havila Shipping ASA, 2016a). The company is now listed as "on special observation" on the Oslo Stock Exchange while trying to come to an agreement with the creditors (Havila Shipping ASA, 2016b).

Pareto Securities characterizes the majority of the offshore supply shipowners listed on the Oslo Stock Exchange as "trading in option territory" (Pareto Securities AS Equity Research, 2016). By this they mean that the threat of bankruptcy is substantial, because as stock prices decline, the likelihood that the amount of outstanding debt will exceed firm value increases. In such an event, stock owners would prefer to exercise their option of giving the debt holders ownership of the firm's assets rather than paying the outstanding debt (Berk & DeMarzo, 2007). However, Fearnley Securities (2015) notes that few bankruptcies have been seen yet, and suggest that this can be explained by the lack of potential buyers in the event of a creditor takeover more than anything else.

#### **2.4.4 Outlook**

Offshore service shipowners expect lower activity, decreased turnover and weaker profit margins for 2016 than 2015 according a survey by the Norwegian Shipowner's Association (2016). They estimate the drop in turnover to about 8 percent. The prognosis for the number of laid up offshore vessels is an increase of 10 vessels by year end, which represents an increase of about 10 percent. The shipowners expect the number of redundant employees to increase over the course of the year. The number of temporarily laid off or terminated employees is expected to be around 1000 to 1500 in the offshore service segment, constituting a significant part of the 4000 to 4500 jobs expected to be cut across all segments for shipowning companies (Norwegian Shipowner's Association, 2016).

Uncertainty about the oil price remains high, which increases the likelihood that the low demand in the offshore segment will persist because uncertainty reduces the oil companies' willingness to invest in exploration and production activities (Pareto Securities AS Equity Research, 2016). Even with a considerable improvement of the oil price in the near future, inertia in the O&G value chain would lead to a significant lag between initiation of new E&P activities and restoration of offshore service vessel demand (Ernst & Young, 2016).

As bank and bond refinancing is made difficult or impossible, restructuring through alternative means of financing, such as institutional investors and private equity becomes more likely. Other initiatives could be consolidation efforts to reduce price pressure through increased supplier power (Ernst & Young, 2016).

### 3. Literature review

Much of the literature used in this section addresses general shipping theory, and is not specific for offshore supply shipping. Most of the available offshore supply literature concerns routing problems, where supply vessels are described in a simplified way. In reality, offshore vessels are heterogeneous so that some vessels will be better suited for a specific task than others (Aas et al., 2009). We have not been able to find literature that directly concerns the lay-up decision for offshore supply vessels.

In most of the literature referred to here, the rate earned by a shipowner is called the freight rate, which is the price of transporting a unit of cargo from one port to another (Stopford, 2009). In offshore supply shipping, the freight rate is the daily fee for chartering a vessel, and is referred to as the day rate.

In this section we will first present an overview of how lay-up can be considered an option. Second, we will look at when the shipowner will decide to lay up a ship. Third we will present some models of the lay-up decision. Lastly we will look at the fleet composition problem and how it affects the lay-up decision.

#### 3.1 The option to lay up ships

To lay up a ship means that a shipowner temporarily withdraws a ship from the market (Tvedt, 2000b). The ship does not produce any output, but will still incur ongoing capital costs and lay-up costs such as watchmen, harbor rent and ship maintenance (Dixit & Pindyck, 1994). A shipowner's opportunity to lay up a ship can be considered an option (Brennan & Schwartz, 1985). The option to withdraw the ship from the market is exercised when freight rates are lower than operating costs, so that shipowners can limit their losses (Tvedt, 2000a).

When a ship is laid up, the shipowner gains the option of putting the ship back into operation. The shipowner either has an option to lay up, or to go back into operation, at all times. Whenever he exerts one of the options, he gets the other one. There is a cost associated with putting a ship in lay-up, and this cost is referred to as the exit cost (when the ship is put in lay-up, it exits the market). There is also a cost associated with taking the ship

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out of lay-up, referred to as the entry cost. In addition, the shipowner incurs ongoing costs while in lay-up, which we will refer to as the lay-up cost (Tvedt, 2000a).

## 3.2 The lay-up decision

The relationship between the freight rate and the operating cost of a ship will in a classical lay-up decision determine whether a shipowner will choose to operate or go into lay-up (Tvedt, 2000b). This means that a ship with a high breakeven point needs a high freight rate to cover its costs, compared to a ship with a low breakeven point (Scarsi, 2007). Thus, the most efficient ship operators put a lower boundary on the freight rate before they exercise the option to lay up a ship. Freight rates will never go below the lay-up level of the most efficient ship, because all ships will be laid up at this level. This means that the option to lay up a ship is more valuable for shipowners with a less efficient fleet than the more efficient shipowners (Tvedt, 2000b).

The option to lay up a ship is more valuable when freight rates are more volatile. High volatility increases the probability for both higher and lower rates in the future. Because the shipowners can choose not to exercise the option if the rates increase, only the probability of lower rates have an impact on the option's value (Tvedt, 2000a).

The combination of uncertainty of the rates and the irreversible exit and entry costs means that it might be rational to delay lay-up until the expected period of lay-up is longer. If the rate increases it would be unfortunate to have the ship in lay-up because the shipowner has to pay the entry cost in addition to already having paid the exit cost. On the other hand, if the freight rate decreases, it would be unfortunate to have the ship in the market, but the exit cost have not incurred (Tvedt, 2000a). The presence of uncertainty, exit and entry costs also means that the rates must decrease further below the operating costs before it is optimal to lay-up a ship (Brekke & Øksendal, 1994).

## 3.3 Models of the lay-up decision

Næss (1992) models day rates using  $p$  as the probability for the rate to increase.  $p$  reflects the market outlook. A high  $p$  ( $p > 1/2$ ) characterizes an optimistic market where shipowners expect rates to increase over time. In an optimistic market, the shipowners will have a lower

threshold to enter the market than in a pessimistic market ( $p < 1/2$ ). This means that the better the future outlook is, the more likely the shipowner is to put his ship into operation if it is in lay-up, and a more pessimistic outlook entails quicker lay-up if the ship is in operation (Næss, 1992).

Similarly to Næss (1992), Dixit and Pindyck (1994) have developed a model where shipowners expect either an increase or a decrease in rates. In this model, they describe how the cost of entry, exit and the ongoing lay-up cost affect lay-up levels. In addition, they describe the shipowner's opportunity to make new investments from scratch, but we do not consider new investments relevant to the lay-up decision, and will therefore leave it out of this discussion.

There are three different thresholds for the freight rate that determines the shipowner's lay-up decision. First, the shipowner will lay-up an operating ship if the rate falls to  $P_L$ . Second, if a ship is already laid up, the shipowner will reenter the market at  $P_R$ . Third, a laid up ship will be scrapped to avoid the lay-up costs if the freight rate reaches the threshold  $P_S$ . At this point, it is unlikely that reactivation will ever occur (Dixit & Pindyck, 1994).

If the reactivation cost increases while the lay-up cost is constant,  $P_R$  will increase and  $P_L$  will decrease. In other words, the threshold for the ships' operation to be reactivated will increase and the rate where the ship is laid up will decrease. Furthermore, when it gets more costly to reenter the market, the option to lay-up a ship loses value, and  $P_S$  rises. This is because a higher cost of reactivating a ship will make reactivation less likely, so that the firm will scrap at a higher freight rate to avoid paying the ongoing lay-up cost. If the reactivation cost is sufficiently high, the shipowner will not consider lay-up as an option, and scrap the ship immediately when the freight rate reaches  $P_S$  (Dixit & Pindyck, 1994).

If the reactivation cost is constant and lay-up cost increases, the savings from laying up a ship is reduced. In this case  $P_L$  will drop, so that the freight rate has to be lower to cause lay-up.  $P_R$  will also drop so that the shipowner will be more willing to put a laid up ship back in the market. Additionally,  $P_S$  will increase, which means that the likelihood for scrapping ships that are already laid up increases with higher lay-up cost. Hence, a high enough lay-up cost will cause the option to lay-up a ship to be worthless. In other words, lay-up will not be used (Dixit & Pindyck, 1994).

## 3.4 The optimal fleet composition

There are several different ways to define the demand for offshore supply shipping services, e.g., in kilometers, pallets, cubic-meters or liters etc. (Redmer, 2015). Vessels have differing abilities to service this demand depending on their specifications. Unpredictability in demand makes the optimal fleet composition uncertain. The fleet composition problem concerns which types of ships to operate and the number of each (Etezadi & Beasley, 1983). The operational fleet has to fulfill market requirements such as the need for tonnage and specific transportation requirements (Redmer, 2015). The fleet composition problem is relevant to the lay-up decision because the shipowners must determine which ships to lay up and which to keep in their operational fleet.

In practice, fleet optimization deals with finding the optimal mix of vessels with different sailing capabilities and capacities. These specifications have to be evaluated against the costs (Schneekluth & Bertram, 1998). We will now look closer at how efficiency, sailing capability, capacity and operating costs affects the optimal fleet composition, and thus which vessels are more predisposed to lay-up.

### 3.4.1 Efficiency

Mossin (1968) and Fusillo (2004) states that the vessels that will be laid up first are the least efficient ones. Efficiency is defined by both speed, waiting time and deadweight utilization, and determines the total transportation capacity of the fleet (Stopford, 1997). Fusillo (2004) also remarks that these would be the oldest ships.

### 3.4.2 Sailing capability

The time a vessel spends on a route is determined by its speed. Lower speed will reduce the transportation capabilities of a shipping company (Stopford, 1997). Different ships are designed with different design speed. In addition, the maximum speed of a ship will be reduced as the ship ages (Stopford, 1997). Consequently, the fleet will have varying average speed over time.

By reducing operating speed, i.e. slow steaming, the shipowners reduce fuel costs due to less water resistance (Stopford, 1997). According to Lyridis and Zacharioudakis (2012) this is often what happens during the through phase. When the market is highly competitive,

shipowners can justify higher rates or attract more shipments by having vessels with high speed in their fleet (Schneekluth & Bertram, 1998). The difference between a vessel's maximum speed and its economic speed, i.e. the difference between how fast the ship is able to go and what speed is most cost-efficient, defines how flexible the ship is. This difference might not always be big, or even present, and this could reduce the vessel's attractiveness (Aas et al., 2009).

For offshore vessels specifically, the fleet's sailing capability also relates to how the vessel is able to handle different weather conditions. Factors such as the machinery and hull design can determine the ability of the vessel to be competitive in the market (Aas et al., 2009). According to Aas et al. (2009), it is more expensive to build and charter a ship with more powerful equipment.

To increase carrying capacity, offshore supply ships are often wide. Wide vessels face higher water resistance and will therefore have higher fuel consumption. If the ship is slimmer, the fuel consumption will be reduced due to lower water resistance, but the ship will either have to be longer, or have lower carrying capacity. If the ship is longer, the hull has to be heavier for the ship to be stable. Consequently it will be more expensive to build. Moreover, a long ship will catch more wind and therefore need more engine power to keep its position and avoid colliding. This entails higher fuel consumption (Aas et al., 2009).

This means that there is a tradeoff in machinery and hull design between the ability to withstand tough weather conditions and fuel consumption. Consequently it is not clear how these specifications will impact the lay-up decision.

### **3.4.3 Capacity**

When the fleet consists of ships with different capacities, it gives the shipowners the flexibility to adapt to the customer's demand by allocating vessels where the capacity utilization will be best (Repoussis & Tarantilis, 2010). For PSVs, the capacity is given by the ability for the vessel to carry deck and bulk cargo. For deck cargo, square meters of clear deck area will define the capacity (Aas et al., 2009). Additionally, Aas et al. (2009) argues that older vessels often lack the strength to carry heavy equipment, whereas newer vessels don't have this problem.

Bulk cargo is transported in separated tanks and the number and size of the tanks determines the bulk capacity. Newer vessels tend to have more tanks than older vessels, and additionally have more efficient cleaning systems for the tanks (Aas et al., 2009).

In some circumstances the shipowner might not be able to fulfill the customer's capacity requirements. This may result in losing the contract to a shipowner with bigger vessels (Taillard, 1999). This indicates that smaller vessels are more likely to be laid up. However, bigger ships generally have higher fuel costs. Taillard (1999) suggests that shipowners should have a heterogeneous fleet, to be able to fulfill different capacity demands.

#### **3.4.4 Operating costs**

According to Stopford (1997) the costs are split into operating costs, voyage costs and capital costs. The operating costs are daily costs of having the ship active in the market plus maintenance costs. The voyage costs arise from making a specific trip, e.g. fuel costs. Capital costs are related to the financing of the ship (Stopford, 1997).

The cost structure is different for old and new ships. Older vessels often have lower capital costs, but operating and voyage costs are often higher than for newer vessels. This is due to the fact that newer vessels often have better technological specifications, such as better fuel efficiency. Ships with better technology might also have automated some of the work otherwise performed by the crew, which will reduce the crew cost. This means that more cost efficient ships can operate at lower rates than the older and more expensive ships (Stopford, 1997). However, the shipowners still have to bear the fixed costs, even though the ship is not operating (Redmer, 2015).

There is also a relation between the size of the ship and the costs, driven by economies of scale. The unit costs can be reduced by employing a larger ship due to its ability to carry a bigger load. The downside with large ships is that the shipowner loses some flexibility, e.g. not being able to enter small ports (Stopford, 1997).

A significant part of a ship's operating costs emerge from crew cost such as wages and insurance. The number of employees on the ship and the policies for the flag state where the ship is registered determines the size of the cost. Consequently, operating costs can be significantly reduced by having fewer workers on a ship and by employing low-cost workers from other countries (Stopford, 1997).

## 4. Methodology

The goal of this thesis is to analyze how the shipowners evaluate whether to lay up a ship, and how they choose which ships to lay-up. To perform this analysis, we have used both a qualitative and an empirical approach. In the qualitative part, we have interviewed seven Norwegian shipowners that operate in the North Sea. These interviews gave us some hypotheses about the lay-up decision that we tested empirically using Ordinary Least Squares (OLS) and logistic regression (logit).

It is our opinion that the qualitative analysis is of value in and of itself. It has enabled us to document how the shipowners evaluate the option to lay up ships, and to assess how closely the literature on the lay-up decision coincides with what we observed in practice. However, we recognize that a qualitative approach is prone to researcher bias, and is not suited to test statistical significance. Therefore, we believe that empirically testing the hypotheses from the interviews strengthens the analysis because it provided an opportunity to check the reliability of our findings.

### 4.1 Qualitative methodology

The use of a qualitative research approach was chosen because it is suited to thoroughly examine a selection of research subjects and thereby gain new knowledge. The non-numeric data highlighted the research subjects' opinions and thereby increased our understanding of their decision making process. The qualitative research method enabled the respondents to give detailed descriptions of their answers, and was suitable to discover connections between the data (Saunders, Lewis, & Thornhill, 2012).

#### 4.1.1 Research design

We have chosen to use an exploratory study. The amount of literature on the lay-up decisions for shipowners is limited. This makes an exploratory research design appropriate to gain new insight to the underlying mechanisms in the market. The benefit of using an exploratory design is that it is flexible, which enabled us to adapt the focus of the thesis as we discovered new information (Saunders et al., 2012).

### **4.1.2 Research approach**

Because there is a limited amount of literature available, we have chosen to use an abductive research approach. This approach involves moving back and forth between data and theory, which allowed us to unveil underlying causes for the shipowners' actions. The advantage of using abduction as our research approach was that it allowed us to analyze the data against the existing literature and thereby draw conclusions for the consistency between the literature and reality (Saunders et al., 2012).

### **4.1.3 Case study**

We have chosen to use a multiple case study in order to gain a broad understanding of how different shipowners react to the lower demand. Case studies are suitable for describing specific situations, but the results are not necessarily generalizable (Saunders et al., 2012). A multiple case study is a suitable research strategy due to the opportunity to gather evidence from several research subjects and gain a broader understanding (Yin, 2012).

### **4.1.4 Data collection**

To be able to get an in-depth understanding of the shipowners' decision making process, we chose to conduct semi-structured interviews. This research method allowed us to gather rich and detailed data from key persons in the lay-up decision. We chose to use one-on-one interviews to collect data because it gave us the opportunity to gain better insight to the reflections and choices of the interviewees. The use of semi-structured interviews allowed us to find causality, highlight new topics that had not been covered in the existing literature, and gave us the flexibility to adapt to new information that surfaced during the interviews (Saunders et al., 2012).

We have chosen to focus on the top management of the offshore shipowners because we are interested in the top level decision making process related to putting ships in lay-up. We aimed at interviewing CEOs in the selected companies, but were open to interview other managers within chartering, operations and finance if the CEO was unavailable. The reason for this approach was that we wanted to talk to the executive decision makers in the companies.

We considered the ability to get access to the relevant information as an advantage of using a personal interview to collect data. According to Saunders et. al. (2012), managers are often more willing to participate in an interview because it makes it easier to gain trust between the interviewer and the interviewee. The reason for this is that a personal interview gives an opportunity to explain how the information will be used, and might therefore achieve a higher response rate (Saunders et al., 2012). We expected the positive response rate to be higher by choosing a personal interview.

#### **4.1.5 Data quality issues**

Research interviews are associated with four main types of data quality issues. These are reliability, bias, generalizability and validity. Reliability is related to whether other researchers would obtain the same data if they were to repeat the study. The lack of standardization in semi-structured interviews makes this type of data collection prone to reliability issues. A related concern is interviewer bias, which means that the behavior of the interviewer can influence the responses. Similarly, response bias can lead the respondent to not reveal information and cast themselves or the organization in a more favorable light. A third type of bias is participation bias, meaning that some potential respondents might decline to participate, for example because of time constraints (Saunders et al., 2012).

Generalizability refers to how applicable the findings are to other settings. With small sample sizes it will not be possible to make statistical generalizations about the population based on the data from the interviews. Finally, validity is related to how successful the researcher is in gaining access to the respondent's knowledge. The language used by the respondents might not be completely clear, and the researcher might misinterpret the responses (Saunders et al., 2012).

#### **4.1.6 Sampling**

##### *Sampling methods*

The population consists of all Norwegian offshore supply shipping companies that operate PSVs and/or AHTSs in the North Sea. Due to time constraints it was necessary to select a sample from the population to make the collection of data through interviews practically feasible.

The population has a large variation among two important dimensions: company size and demonstrated willingness to put ships in lay-up. We decided to target companies that would differ along these dimensions. Consequently, we used what Saunders et al. (2012) characterizes as a heterogeneous sampling technique, where the researcher uses judgement to find interview subjects that are diverse. This sampling technique is appropriate when wanting to capture a range of views, and allows the researcher to document key themes and uniqueness while maintaining a low sample size (Saunders et al., 2012).

Due to time constraints, the geographical locations were limited to the regions around Bergen and Ålesund. This excluded some large shipowners such as Siem Offshore and Viking Supply located in Kristiansand. In addition, Solstad Offshore near Haugesund declined to be interviewed.

Consequently, the sample was conducted using non-probability techniques that lead to a non-random sample. Non-probability techniques have the disadvantage that they may introduce bias to the sample (Saunders et al., 2012). The reader should be aware that the results drawn from our analysis are dependent on the interview subjects chosen, and may not be representative for the industry as a whole. In an attempt to increase the generalizability of our findings, we asked the respondents how they thought other shipowners might consider the lay-up decision. This was done so that any outliers would be discovered.

### ***Sample size***

Choosing the sample size can be a tradeoff between representativity and accuracy. Larger samples will be more apt to draw generalizations from, while smaller samples allow for more time spent on each subject, which will make in depth analysis more manageable (Saunders et al., 2012).

Because of the extensive nature of semi-structured interviews, we chose to limit the number of interview subjects to seven. Saunders et al. (2012) quotes 5 to 25 participants as appropriate when using semi-structured interviews. They suggest that new interviews should be conducted until data saturation is reached, meaning that the data collection should end when little or no new information is uncovered from interviewing new subjects (Saunders et al., 2012). During the later interviews we conducted, we noted that little new information was uncovered.

### *Contacting potential respondents*

After selecting which companies to include in the sample, we sent out emails with invitations to participate in an interview. In addition to asking the recipient to participate, the invitation gave a brief description of the topic for our thesis. A translation of the invitations can be found in appendix A.

Four of the shipowners accepted our first invitation. We chose to send out a reminder email to the companies that had not replied to our initial request. In this reminder, we stated that we would not mind interviewing any other members of the top management if the CEO was unavailable. After this reminder, three more companies agreed to be interviewed.

Havila's CEO had initially agreed to be interviewed, but due to unforeseen circumstances he was not able to attend. We were offered to interview the COO instead, which we accepted. Volstad's CFO offered to participate after we sent the reminder email because the CEO was unavailable. Shipowner2's CEO did not reply, but a manager within chartering was able to participate. This is the only interview subject that is not a part of top management.

### **4.1.7 The interviews**

#### *Interview guide*

Prior to the interviews, an interview guide was prepared. The questions in the interview guide was developed by expanding on the research questions, while taking the relevant theories from the literature review into consideration. The sequence of the questions in the interview guide had the following structure:

- First we asked general questions about how the company has adapted to the new market conditions and lower day rates
- Second we asked questions about the decision to lay up a part of the fleet, and the analysis that preceded such a decision
- Third we asked questions specifically about how the company determined which vessels would be laid up
- Finally we asked if there was anything the interviewee would like to add before finishing the interview

This structure of going from general to specific was chosen in order to ensure that we had a common understanding of the topics for discussion, before closing in on the more detail

oriented questions. If the interviewee had a different understanding of the situation, we wanted this to be uncovered as soon as possible. The interview guide can be found in appendix B.

Having one common interview guide ensured consistency and coherency between the different interviews, and made comparison between the interviews easier for the analysis. Some company specific questions were added when appropriate, e.g. we did not ask the shipowners with homogenous fleets how vessel characteristics affected the lay-up decision.

The questions were worded to be non-leading to lower the risk that our own opinions would impact the responses. Non-leading questions improves the reliability in interview settings (Brinkmann & Kvale, 2015).

Because of the nature of semi structured interviews, we expected some diversion from the interview guide. We saw this as advantageous because it would allow the conversation to flow more freely, and let the interviewees respond by association without feeling constrained. The exploratory nature of our research supported this approach. During the interviews, some of the respondents commented that our questions were vague. In these instances, we provided more specific questions. We asked follow up questions when appropriate.

### *The interviews*

All interviews were conducted in the companies' own offices, for the convenience of the interview subjects. This enabled us to have face-to-face conversations in an environment the interview subjects were familiar with. After arriving on site and greeting the interview subjects, we asked them if they accepted that the conversation was recorded. All respondents accepted that the conversation was recorded.

We expressed to the respondents that we wanted to use the company's name in our thesis, but offered anonymity if they preferred that. Two of the respondents opted for anonymity. We have chosen to label these companies as Shipowner1 and Shipowner2 in the analysis section. The interviews differed in length, depending on how talkative the interviewees were. Some were very responsive and seemed to find the questions engaging and interesting. Others were more guarded and reluctant to share information. The shortest interview lasted

for 20 minutes and the longest for just over an hour. All the interviews were conducted in Norwegian.

#### **4.1.8 Post interviews**

##### *Transcribing*

Each interview was transcribed by us, the interviewers, within two days of conducting the interview. In total, there were 4.6 hours of recordings which resulted in 72 pages of transcribed material.

Transcribing from oral to written form introduces interpretational issues. Particularly whether to preserve the conversation verbatim, or to introduce a more formal written style (Brinkmann & Kvale, 2015). We considered the linguistic style of the interview subjects to be of little importance and chose to adapt a more formal written style. The recordings were of high acoustic quality, which reduces the chances of mishearing and misinterpretation. This is thought to improve the reliability of the transcriptions (Saunders et al., 2012).

##### *Performing the analysis*

Collection, processing and analysis of qualitative data are interrelated processes, and to some extent the analysis process began as we were conducting the interviews (Saunders et al., 2012).

After conducting the first five interviews, we summarized our findings at the time, and our confidence level on the findings. We noted which questions needed to be answered in order to increase the confidence level through improving the quality of our data and seeking alternative explanations. This interim summary was used to make adjustments to the interview guide before the final two interviews.

Using the interview guide as a template, we gathered the different interviewees' answers to each question in order to compare and contrast the responses. Using our best judgement, we grouped together responses that were similar in order to form an opinion on whether there was a consensus between the respondents on certain questions, or whether there appeared to be a disparity or inconsistencies between them.

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## 4.2 Empirical methodology

Two econometric techniques have been used to test some of the hypotheses we formulated after conducting the interviews. First, Ordinary Least Squares (OLS) was used to investigate how lay-up levels correlate with day rates and the variance of day rates. Second, logistic regression (logit) was used to investigate how the specifications of a given vessel impact the likelihood that it will be laid up.

### 4.2.1 OLS

OLS is a regression technique used to analyze the relation between a dependent variable and one or more independent variables. The regression equation can be expressed as:

$$y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_k x_k + \varepsilon$$

where  $y$  is the dependent variable,  $\alpha$  is the constant term, the  $\beta$ s are the independent variables' parameters, the  $x$ s are the independent variables and  $\varepsilon$  is the error term.

The  $\beta$ s reflects the degree to which the dependent variable correlates with the given independent variable. In the regression, coefficients are produced as estimations for each of these parameters. The estimation is done by minimizing the sum of the squared residuals, where the residual is the difference between the observed value and the expected value for a given observation of the dependent variable (Maddala & Lahiri, 2009; Hair Jr, Black, Babin, Anderson, & Tatham, 2006).

Independent variables that represent qualitative factors are represented with dummy variables that indicate whether a certain characteristic is present (Hill, Griffiths, & Lim, 2012). We used dummies for the month and year the observation was made to control for seasonal factors.

#### *Interpreting the results from OLS*

The coefficients from the regression are the estimated change in the dependent variable for a one unit change in the coefficients' corresponding independent variable, when all other independent variables are held constant. If the coefficient is positive, the dependent variable is expected to increase when the independent variable increases, and vice versa for a

negative coefficient. If the coefficient is zero, the independent variable has no estimated correlation with the dependent variable (Hair Jr et al., 2006).

For dummy variables, the coefficient represents the estimated change in the dependent variable when the dummy characteristic is present, as compared to a base case (Hill, Griffiths, & Lim, 2012). E.g. if a dummy represents the month the observation was made, and January is the base case, the coefficient for February will represent the estimated change in the dependent variable for an observation made in February as compared to January.

The constant term is the estimated value of the dependent variable if all independent variables are zero. However, there is often a lack of observations in that range, and in such cases the constant term is not reliable (Hill et al., 2012).

### ***Statistical significance***

Each independent variable is included in the model because we believe they explain some of the variation in the dependent variable. To investigate whether the data indicates that this is the case, a t-test is used for each coefficient. The null hypothesis is that the true coefficient equals zero so that the variation in the given independent variable does not explain any of the variation in the dependent variable. The alternative hypothesis is that the true coefficient does not equal zero (Hill et al., 2012).

The t-test is performed by computing a test statistic, the t-value, based on the ratio between the coefficient and its standard error, which is a measure for the coefficient's error margin. In simple terms, we want to test whether the coefficient from the regression is large enough in absolute terms relative to the deviation in the estimate, so that we can conclude that the coefficient is truly different from zero, and not just a result of sampling error. The output from the OLS-regressions will report a p-value which indicates the likelihood that the coefficient is zero (Hill et al., 2012).

### ***Goodness of fit***

The coefficient of determination,  $R^2$ , is a measure for the overall fit of the model. It measures the proportion of the variance in the dependent variable that is explained by variation in the independent variables.  $R^2$  can range from 0 to 1. If  $R^2$  is 0, none of the variation is explained by the model. If  $R^2$  is 1, the model perfectly predicts the dependent

variable. If  $R^2$  is somewhere in between, e.g. 0.4, the interpretation is that 40 percent of the variation in the dependent variable is explained by the model (Hill et al., 2012).

### ***Assumptions***

The following assumptions are made about the variables and the random errors (the random errors are the differences between the observed and the expected value of the dependent variable):

1. The dependent variable is linearly related to the independent variables
2. Each random error has a probability distribution with zero mean
3. Each random error has a probability distribution with constant variance
4. The covariances between random errors are zero
5. The independent variables are not exact linear functions of other independent variables
6. The random errors are normally distributed

(Hill et al., 2012).

### **4.2.2 Logit**

The logistic regression (logit) is a form of nonlinear regression that is used to model binary outcomes. The technique is suited to analyze “either-or” situations where the dependent variable can take one of two possible values (Hill et al., 2012). The binary outcome in our case is whether or not a specific ship is laid up, and can be expressed as:

$$y = \begin{cases} 1 & \text{if the ship is in laid up} \\ 0 & \text{otherwise} \end{cases}$$

With binary outcomes, there is no meaningful interpretation of a situation where the dependent variable is between 0 and 1 (Tufté, 2000). A ship is either laid up or it is not. There is no middle ground. However, OLS will treat the dependent variable as continuous. To overcome this discrepancy, it is assumed that the binary outcome is the observable manifestation of an underlying, so called latent, variable which is continuous (Maddala & Lahiri, 2009). In our case, the latent variable will be a shipowner’s propensity to put a ship in lay-up.

The latent variable can be seen as the probability that the outcome is 1. When the model predicts a probability greater than 0.5, the predicted outcome is 1. When the predicted probability is equal to or lower than 0.5, the predicted outcome is 0 (Hair Jr et al., 2006).

Additionally, there are no meaningful interpretations of outcomes that are lower than 0 or higher than 1. OLS treats the dependent variable as though it has an unrestricted sample space. To solve this, the logit technique uses logistic transformation to reformulate the dependent variable so that it is no longer restricted to the interval from 0 to 1 (Tuftte, 2000).

The upper bound of the sample space is removed by transforming probabilities to odds (odds transformation). For a given event, odds are the ratio between the probability of occurrence, over the probability of nonoccurrence. If the probability for occurrence is  $p$  and the probability for nonoccurrence is  $(1-p)$ , then the odds are

$$\text{odds} = \frac{p}{1-p}$$

and has a sample range from 0 to positive infinity (UCLA Institute for Digital Research and Education, n.d.).

We are now left with the lower bound, which is removed by transforming odds to the log of odds (log transformation). The log of odds, also referred to as the logit, can be expressed as

$$L = \ln(\text{odds}) = \ln\left(\frac{p}{1-p}\right)$$

and has a sample range from negative infinity to positive infinity (Tuftte, 2000).

Both the odds transformation and the log transformation are monotonic, meaning that the ordering is preserved, even though the magnitudes have changed. A higher probability relates to higher odds, which again relates to higher log odds. (UCLA Institute for Digital Research and Education, n.d.). The logit is then used as basis for linear regression with the independent variables. The model can be formulated as

$$L = \ln\frac{p}{(1-p)} = \alpha + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k$$

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where  $x_1, \dots, x_k$  is the set of independent variables, and the parameter values  $\alpha$  and  $\beta_1, \dots, \beta_k$  are estimated using the maximum likelihood function (UCLA Institute for Digital Research and Education, n.d.). Unlike OLS, where the goal of the regression is to minimize the square of the error terms, maximum likelihood uses an iterative process to find the coefficients that maximizes the likelihood that we would get the observed outcomes. In logistic regression, it is the log of the maximum likelihood function (the log likelihood function) that is maximized (Hair Jr et al., 2006; Tufte, 2000).

### ***Interpreting the results from logistic regression***

Interpreting the results from logistic regression is not straight forward because the dependent variable is the logit, not the probabilities. The coefficients are measures of the change in the odds, expressed in terms of logarithms (Hair Jr et al., 2006).

The constant term  $\alpha$  shows the average logit when all other independent variables equal zero. The other coefficients show how much the logit changes when the associated independent variable increases with one (Tufte, 2000). Because the transformation from probability to logit is monotonic, the direction of the relationship between coefficients and probabilities can be interpreted in the same way as with OLS regression: A positive coefficient means that the predicted probability increases when the related independent variable increases, and vice versa for negative coefficients (Hair Jr et al., 2006).

### ***Statistical significance***

Statistical significance of coefficients in logistic regression can be tested by calculating the asymptotic standard error. The z-test can be used to test the null hypothesis that the coefficient equals zero. Coefficients in logistic regression are normally distributed when the sample size approaches infinity. This implies that the z-statistic is only reliable for large sample sizes. What constitutes a large sample size is not easily defined, but the sample size should not be smaller than 100, and preferably larger than 500 (Tufte, 2000).

### ***Goodness of fit***

$R^2$  can be used as a measure of the explanatory power of a logistic regression. Like with OLS, it measures how much of the variation in the dependent variable that can be explained by the predicted probabilities from the regression. However,  $R^2$  in this context is problematic because the value can decrease by introducing another independent variable, even though it has a positive contribution to the log likelihood function. Instead, pseudo- $R^2$  is commonly

used as an approximation. It uses the log likelihood function to evaluate the criteria that have been used to estimate the parameters in the regression. Stata reports a pseudo- $R^2$  that range from 0 to 1. A higher pseudo- $R^2$  implies that more of the variation in the dependent variable is explained by the model. A pseudo- $R^2$  of 0 implies that the model does not explain any of the variation in the dependent variable. Unlike with  $R^2$  in OLS, the pseudo- $R^2$  has no natural interpretation, but the values can be used to assess different models with the same dependent variable against each other (Tufté, 2000).

### *Assumptions*

In addition to the already mentioned assumptions, the observations are assumed to be drawn from a random sample and thus independent from each other, and there is assumed to be no multicollinearity, as in OLS (Tufté, 2000).

## 5. Analysis

We will now present the findings from our research, and analyse the results. Section 5.1 covers the qualitative analysis and section 5.2 covers the empirical analysis.

### 5.1 Qualitative analysis

In this section, we will use the information from the interviews to evaluate if the theories described in the literature review provides an accurate description of the situation that has unfolded during the decline in offshore activity in 2014 to 2016. We will also provide documentation on aspects that impacts the lay-up decision that are not covered well in the existing literature.

In section 5.1.1 we will provide an overview of the respondents. In section 5.1.2 we will discuss which factors shipowners take into account when deciding whether or not to put a ship in lay-up. In section 5.1.3 we will describe the characteristics of lay-up as an option in practice. In section 5.1.4 we will elaborate on how specific vessel characteristics and the optimal fleet composition impact which vessels are laid up. In section 5.1.5 we will discuss likely changes in the industry if the current downturn continues. In section 5.1.6 we formulate some hypotheses that we will test empirically in section 5.2.

#### 5.1.1 Respondents

Table 5.1 shows the companies that make up the interview sample, in the order the interviews were conducted. Also included is the companies' geographic location, fleet size and number of vessels laid up around the time of the interviews.

Table 5.2 shows the name and title of the interviewees from each company. Note that Remøy Management is a management company that does not own vessels, but operate them on behalf of shipowners. The offshore fleet they operate is owned by World Wide Supply.

*Table 5.1: Overview of the interviewed companies, their location, fleet size and number of vessels laid up*

<b>Company name</b>	<b>Geographic location</b>	<b>Fleet size (22-Apr-2016)</b>	<b>Vessels laid up (22-Apr-2016)</b>
<b>DOF</b>	Bergen (Austevoll)	PSV: 19 AHTS: 22	PSV: 0 AHTS: 0
<b>Shipowner1</b>	Removed for anonymity purposes	Removed for anonymity purposes	Removed for anonymity purposes
<b>REM Offshore</b>	Fosnavåg	PSV: 10 AHTS: 1	PSV: 4 AHTS: 0
<b>Havila Shipping</b>	Fosnavåg	PSV: 14 AHTS: 5	PSV: 2 AHTS: 2
<b>Volstad Shipping</b>	Ålesund	PSV: 3	PSV: 2
<b>Remøy Management/ World Wide Supply</b>	Fosnavåg	PSV: 6	PSV: 6
<b>Shipowner2</b>	Removed for anonymity purposes	Removed for anonymity purposes	Removed for anonymity purposes

*Table 5.2: Name and title of interviewees*

<b>Company name</b>	<b>Interviewee</b>	<b>Title</b>
<b>DOF</b>	Mons S. Aase	CEO
<b>Shipowner1</b>	Removed for anonymity purposes	Removed for anonymity purposes
<b>REM Offshore</b>	Åge Remøy	CEO
<b>Havila Shipping</b>	Kjell Rabben	COO
<b>Volstad Shipping</b>	Torstein Heggstad	CFO/Deputy CEO
<b>Remøy Management/ World Wide Supply</b>	Even Remøy	CEO
<b>Shipowner2</b>	Removed for anonymity purposes	Removed for anonymity purposes

### **5.1.2 The lay-up decision**

The shipowners unanimously agree that cutting costs is the most important factor when they evaluate whether or not to lay up a ship. However, we have found that the shipowners take several other aspects into consideration. From the interviews we discovered that these are: limiting supply, the market outlook, startup costs for new vessels, lay-up costs versus operating costs, the opportunity to scrap or sell vessels, and employees and competence.

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### *Limiting supply*

All the respondents agree that the desire to reduce supply is a widespread concern for most shipowners when deciding to lay up a ship. By reducing supply, the part of the fleet that is still operational will benefit from higher day rates. Because the offshore supply industry is fragmented with many small and medium sized players, individual shipowners should not be able to significantly impact supply. However, during our interviews we discovered that through signaling and expectations between the shipowners, they manage to align their efforts in laying up ships to some degree, so that in sum they do manage to positively influence day rates. This is a form of tacit collusion that is not illegal, but enables the shipowners to exert a degree of supplier power that they would not be able to achieve individually.

All the respondents with the exception of DOF agree that when you lay up a ship, you send a signal to other shipowners that “we are taking responsibility to restore the balance in the market, and you should contribute as well”. There is no formal cooperation, but all the shipowners observe what the others are doing and know how this signaling works. It is expected that everyone should contribute equally relatively to their portfolio, not necessarily with an equal amount of ships.

DOF is the only respondent who say that they have not taken supply reduction into account. They state: “In all fairness, everyone should contribute to get the market back on track, but that is not a consideration we have made. We have been cynical and thought only of ourselves.” A possible explanation for DOF’s “lack of collegial attitude” as they themselves call it, is that they have low spot exposure and a high proportion of their vessels on term contracts which makes lay-up less relevant for them.

Even though the other respondents say that they want to reduce supply by laying up ships, it is common to still offer the laid up ship in the bidding process for new term contracts. Lay-up is usually considered as an alternative to trading in the spot market when the ship does not have a term contract. So by entering lay-up, supply is reduced in the spot market. But by offering laid up ships for term contracts, lay-up will in practice increase supply in the term market, and contribute to keeping term rates low. This indicates that overall supply is not necessarily reduced when a ship is laid up, but rather the supply shifts from the spot market to the term market.

This indicates that companies with high contract coverage, such as DOF, have smaller incentives to put their ships in lay-up. Since the lay-up decision only has a positive effect on the spot market, they will not benefit from reducing the supply by laying up ships in the spot segment. DOF has made an effort to build a global organization in order to increase the amount of contracts they are able to bid on. This makes it easier for them to turn to other markets when demand is low, rather than laying up ships.

Additionally, companies with low spot exposure might have good profits from their ships on contracts, and are therefore able to trade a few ships in the spot to keep their organization going. DOF's strategy is to keep as many vessels as possible operational, and sees this as more important than the opportunity to save costs short term by laying up vessels.

### ***Market outlook***

A prerequisite for the option to lay up a ship to be valuable is that market conditions are expected to improve over time. Because there is a cost associated with having ships in lay-up, shipowners would rather sell or scrap their vessels if they did not expect to gain from higher future day rates when the market improves. The respondents unanimously agree that the day rates will go back up again, but they also agree that it will take time. Several of the respondents call attention to the fact that the current market conditions are not solely a result of the low oil price. Even without the lower oil price there would have been an overcapacity of ships. This overcapacity stems from new entrants as well as old players that have expanded their fleet.

The interviewees are preparing for a long through phase with low freight rates and high competition. REM is preparing to handle a weak market until the end of 2019. In other words, the current market outlook is pessimistic, even though the shipowners expect a recovery to occur eventually. As mentioned in the literature review, a pessimistic outlook indicates that the lay-up period will be longer. This is confirmed by the respondents who state that a peak in day rates is not enough for them to reenter the spot market with their laid up vessels. There needs to be a lasting, upwards shift in day rates. We will elaborate on this in section 5.1.3 when discussing the strike price.

Næss (1992) states that a pessimistic market leads to quicker lay-up. This seems to be the case, seeing as many shipowners choose to put their ships directly in lay-up after completion of a term contract instead of testing the waters in the spot market first. Most of the

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respondents agree that if they are to lay up another vessel, the most likely trigger would be that a ship comes off a term contract. REM explains: “We have several ships coming off contract towards the end of 2016. It is obvious that if the day rates in the spot market are half of operating costs, they will have to be laid up.”

### *Start up costs for new vessels*

The fact that some newbuilds have been delivered at the same time as ships have been laid up is an indication that the market outlook has changed drastically over the last few years. The ships being delivered today were contracted in 2013 and 2014 when shipowners were more optimistic about future day rates. Even though the outlook has changed, cancellations and delays are expensive, so many of these ships are being delivered even though there is an oversupply of vessels. An example of this is the PSV Blue King which is owned by Blue Ship Invest and managed by Golden Energy Offshore. The vessel went straight from yard to lay-up when it took delivery in April 2015 (Flaaten, 2015).

None of our respondents have laid up newbuilds directly from yard, but they explained the reasoning behind such a decision on a general basis. If the ship does not have a contract when it is delivered, the shipowner may recognize that putting the ship in the spot market will result in a greater loss than directly laying up the ship. There is an initial cost of getting a newbuild operative. When the ship is finished at the shipyard, it has to be supplemented with equipment etc. before it can enter the market. By putting the ship directly in lay-up the shipowner can postpone this cost until the market and the company’s liquidity gets better.

If a shipowner have not yet hired a crew for the ship, it will be easier to put the ship directly in lay-up. In that case, the shipowner does not have to consider temporary layoff and termination of crew. This can be cost saving and shield both the employees and the management from the negative effects layoffs and termination have on a firm.

Additionally, customers are often reluctant to give contracts to newbuilds due to the possibility of startup problems. Even in a good market shipowners normally have to lower their rates to get a contract for a new ship. But in today’s pressured market the opportunity to reduce rates more than they already do with their seasoned ships is very limited.

Volstad mentions that if a newbuild was built for a contract, the customers might need the ship in 2017 or 2018, but not today because of the reduced offshore activity. The customer

can then offer to pay the lay-up costs in exchange for lower day rates if they go directly to lay-up. If they had an agreement for a five year contract and they push the contract one year forward, the customer pays the lay-up cost for a year and the ship still has the five year contract starting next year. This might strengthen the attractiveness of lay-up.

During the interviews, some of the respondents also bring up capital expenses as a reason why newbuilds might go directly into lay-up. The argument is that because newbuilds have higher capital expenses, they have a higher overall cost level than an older vessel where a proportion of the loans have been repaid. However, capital expenses should not be taken into account in this decision, because lay-up does not excuse the shipowner from paying these expenses. But because newbuilds are usually more valuable, they will consequently be insured at a higher premium than older vessels. Several of the respondents report that insurance costs are reduced when a ship is in lay-up. This could mean that the value of the vessel makes newbuilds more prone to lay-up, even though the capital expenses are unaffected by lay-up.

### *Lay-up costs versus operating costs*

The respondents report substantially different daily costs for having a ship in lay-up. REM says that their daily lay-up costs are approximately NOK 10.000 per vessel, which is 60.000-NOK 70.000 lower than their daily operating costs. Volstad also says that they have about NOK 10.000 a day per vessel in lay-up costs. They own their own quay, and thereby avoid paying harbor rent. They have two employees on shift onboard at all times to perform maintenance and for security reasons.

DOF on the other hand, reported daily lay-up costs of NOK 20.000-30.000, which is significantly higher than REM and Volstad. When lay-up costs are higher, the savings from laying up a ship is lower. According to Dixit and Pindyck (1994), DOF would have to experience lower day rates before they lay up their ship than REM. At the time of the interview, REM had four ships in lay-up whereas DOF had none. However, this might be a result of DOF's strong wish to keep all their ships operative, rather than differences in lay-up costs. Havila also supports Dixit and Pindyck's (1994) statement that the option to lay-up a ship loses value if lay-up costs are high enough. As Havila said: "you can put a ship in warm lay-up, but that will be almost as expensive as trading it".

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The respondents state that there are some economies of scale in lay-up costs. Shipowner1 points out that the shipowner might be able to reduce the cost per ship if more than one ship is laid up at the same location. If they install onshore power supply, the costs can be divided between more vessels. Remøy Management and Havila mentions that the need for watchmen does not increase proportionally to the number of ships in lay-up. For instance, Havila has two people watching after all of their laid up ships. Whether there is five or seven ships will not affect the crew costs since the need for watchmen stays the same. Economies of scale strengthen the attractiveness of laying up additional ships due to the increasing difference between daily operating costs and the daily lay-up costs. This implies that shipowners will be more likely to lay up a ship if they already have a ship in lay-up, provided that they can co-locate their laid up vessels.

### ***Scrapping, sale and lay-up***

Dixit and Pindyck (1994) suggest that if the day rate is low enough, it will be optimal for the shipowner to scrap the ship instead of keeping it in lay-up. Because the Norwegian offshore supply fleet is relatively new, none of the firms have used the option to scrap ships. The scrap value is not high enough to justify scrapping of a young ship. Shipowner2 and DOF state that because the amount of recoverable steel in offshore supply vessels is low, scrapping values are very limited. When factoring in sailing costs of bringing a ship to the scrapyards, the scrapping value might actually be negative. When scrapping values are low, lay-up becomes a more preferable alternative.

If a shipowner wants to part with a ship, there is a second option in addition to scrapping, which is selling the ship. The firm will choose to sell the ship if the salesprice is higher than the scrapping value. Some of the respondents have sold ships during this through phase.

Shipowners may consider sale of a vessel as an alternative to lay-up in order to avoid the lay-up costs. The deciding factors will be the offered price versus lay-up costs, in addition to the need for capital. A ship that is laid up at a harbor is capital intensive. The banks need the loans repaid for both long and short debt cycles, and unlike lay-up, selling a ship to repay loans would relieve some of this pressure.

If the shipowner sells to a competing business, the supply of ships in the market will not be reduced. Several shipowners have considered selling ships to other markets such as the wind industry or rebuilding their ships to well boats for carrying fish. In this case, the supply of

ships will be reduced because the vessels exit the offshore supply market. Like with scrapping, this will have a permanently positive impact on day rates and should therefore be more attractive than selling to a competing business.

Vessel values are under strong pressure because the industry is experiencing a downturn worldwide. Volstad points to the fact that they have not considered selling to anyone in oil and gas due to the fact that there are no buyers with a high enough willingness to pay. Shipowner2 has sold some vessels, but states that the sales prices were far below the fair value of the ships. This was done in order to avoid the operating and maintenance costs associated with owning an older vessel, and because they did not believe the ships would have a future when the recovery phase starts.

We see that low scrapping values and the strong downwards pressure on vessel values makes scrapping and sale of vessels less preferable alternatives for shipowners. This increases the attractiveness of putting ships in lay-up.

### ***Employees and competence***

Some shipowners say that termination of employees can influence the lay-up decision because the loss of competence can impact their ability to do well during the recovery phase. The shipowners differ in their opinion on how important the loss of competence will be for the future. They have also chosen different approaches to the decision between temporary layoff and termination of employees that become redundant when ships are laid up.

Havila has gone directly to termination because they think the downturn will last for more than a year, which is the length of the temporary layoff period. They have found it necessary to terminate employees with key competence that they do not want to lose. They expect that many of the skilled workers that have been terminated will not be available when they need them again. However, they do not think that this will limit their ability to recover after the through phase.

REM has also chosen not to make use of temporary layoff, and instead immediately terminated employees when they have laid up vessels. But unlike Havila, they think that many of their previous employees will not be able to find relevant work in the offshore industry, and therefore will be available for rehire when the recovery phase begins. This difference in perception between REM and Havila is particularly interesting because they are

located in the same geographic area. However, keeping key competence in the company is an important concern for REM when it comes to their only AHTS. They say that they would under no circumstance lay up this vessel, because it requires more specialized competence than a PSV, and they are not willing to risk losing that competence.

DOF has not terminated anyone yet, but if it comes to the point where they would have to terminate employees, they do not think this would stop them from being able to do well during the upturn. They argue that they are such a big firm that they would have enough diversity in the remaining employees' core knowledge.

Shipowner1 also wants to keep their competence in the firm, and does so by trying to relocate key people to other vessels. But they think that the layoff rules are not good enough for the time frame they have for their lay-up period and therefore went straight to termination when they laid up their first ship.

Remøy Management states on behalf of World Wide Supply that they have the same approach to termination as in Shipowner1. They have gone directly to termination, but have chosen to keep the key competence by giving them administrative employment internally in the organization. This enables them to keep some employees so that they can train new employees if necessary in the future.

Shipowner2 invests heavily in human capital, and therefore wants to keep as many employees as possible. They are willing to pay a price to keep some ships in the market to keep their crew until the market improves, even though it results in a short term loss.

Volstad does not want to terminate their employees. They have chosen temporary layoff to keep the employees competence in the company when they have laid up vessels. They are the smallest of the interviewed firms, they only have Norwegian crew on their PSVs, and the top management visits all their ships twice a year. It is very important for them to keep their employees, not only for the competence but also because they know them on a personal level. Volstad say that the cost of employing the wrong person is so big that as long as they think that they are going back again one day they are willing to take the cost of trying to keep their employees for so long that they can put them back into work.

Overall, temporary layoff is seen by most of the respondents as unfavorable compared to immediate termination, due to their conviction that the through phase will last longer than what the layoff rules allow.

### **5.1.3 The option to lay up ships in practice**

We will now look at how the option to lay up ships works in practice, by looking at when the option will be exercised, the strike price and the volatility of day rates.

#### ***Exercising the option***

REM is the only company that reports to have an explicit lay-up limit. When the day rates are on average NOK 10.000 lower than their operating costs, the difference equals their lay-up cost. REM will therefore put a ship in lay-up if the loss of operating is higher than NOK 10.000 per day. The other respondents report that if the income becomes lower than the operating costs, they will evaluate if the situation is short term or long term. If their forecasts indicate that the operation will be unprofitable for a longer period of time, they will go into lay-up.

#### ***Strike Price***

Shipowners use lay-up as a way of reducing costs, but there are also costs of going into lay-up. This is called the lay-up option's strike price. The shipowners all agree that the direct cost of going into lay-up is very low. If the vessel needs to be relocated to the lay-up harbor, there will be a transit cost, but in the greater context over a year or two this amount is negligible.

If the lay-up leads to termination of employees, the shipowner will incur crew costs during the employees' notice period. If the shipowner instead chooses temporary layoff, they have an obligation to pay ten days wage, and additionally five more if they want to extend the lay-off beyond the first 30 weeks. Other direct costs of putting a ship in lay-up are situational. They might have fuel, food or water that can either be moved to other ships, or they can let it go to waste. But none of these costs are of big significance for the shipowners when they evaluate if they should go into lay-up or not.

Even though the direct costs of going into lay-up are low, there can be significant costs associated with putting the ship back in operation after being laid up. There are mobilization

costs such as getting the crew back on the ship as well as restarting all the technological equipment. All the shipowners point out that if all the technology on the ship is working, it is easy and not very costly to go back into operation. This will likely be the case if the ship is in lay-up only for a short period of time.

The cost of going out of lay-up increases over time when the ship is in lay-up. A ship that is not in operation deteriorates quickly, and there is no simple answer to what the cost will be when it reenters the market. In the hope of reducing the costs of going out of lay-up, it is common to occasionally start the engines and let them run for a while for maintenance purposes.

The timing of when the ship is put in lay-up also affects the entry cost. The cost of going out of lay-up will be higher if vessel maintenance and renewal of certificates has been postponed, so that the shipowner has to pay for these before the ship reenters the market. For example, Havila's AHTS Havila Neptune had reached the point where it had to go to the shipyard for overhaul of its machinery. Havila thought that they could not justify spending a significant amount of money on an overhaul considering the market at the time, and therefore put the ship in lay-up. If they are to start operating the ship again, they will have to pay this cost. Thus, the cost of going out of lay-up will vary with the ship's current condition when it goes into lay-up and the duration of the lay-up.

The costs of going out of lay-up can be seen as an indirect costs of going into lay-up, because customers may be reluctant to award contracts to ships that are in lay-up. The reason for this is inertia in the process of taking a ship back in the market after lay-up, such as the need for maintenance at a shipyard. There is also a risk for technological or mechanical problems after a period of lay-up. Unless there is some specific technology they need, customers would often rather choose a ship that is operational. The indirect cost of going into lay-up increases the strike price of the lay-up option, even though it is not paid up-front. This will reduce the attractiveness of lay-up.

In addition to reducing the attractiveness of lay-up, Dixit and Pindyck (1994) states that a higher cost of going out of lay-up will increase the day rate-level where the firm will reenter the market. This is in line with what we have uncovered in the interviews. The respondents say that contracts or a good, stable spot market are the reasons for reentering the market. They unanimously agree that they will not enter the spot market again until the market is

stable at day rates well above operating costs. They add that they will not reenter if there's just a peak in the day rates. The reason for this is that if the rates increase slightly above operating expenses and a lot of ships reenter the market, the market will collapse again and they will have to pay the strike price once more. Thus, as Dixit and Pindyck (1994) anticipated, the reentry cost will result in the shipowners waiting for better and higher rates before they reenter the market. However, the part of the reentry costs that would have to be paid even if the ship was operating, e.g. maintenance of the engines, will not reduce the attractiveness of the option to lay-up a ship. Rather, the opportunity to postpone this expense makes lay-up more attractive because of the time value of money.

### *Volatility*

Tvedt (2000a) states that when there is a cost of entering and exiting lay-up, it might be rational to delay lay-up until the expected lay-up period is longer. We have seen that exercising the option to lay up, and exercising the option of taking a ship out of lay-up, is not frictionless. There are costs associated with both, particularly the latter. This gives the shipowners an incentive to tolerate a period of low day rates without resorting to lay-up, if they expect the rates to improve. If day rates improve, the shipowners will be better off if they have not put their ships in lay-up, because they avoid both the cost of going into and out of lay-up.

One of the shipowners mention that seasonality effects makes AHTS rates more volatile than PSV rates, and that this can be a reason to delay lay-up for an AHTS. If they expect the rates to improve over time, they would rather keep the vessel in the market for a while longer even though it is unprofitable at the moment, because the anticipated day rate increase would make up for the loss.

The respondents report that they do try to anticipate whether a drop in day rates will last long term before they lay-up a ship, but several of them mention that they do not use formal models to calculate whether lay-up is the most advantageous alternative. This suggests that volatility is taken into account to some degree, but not by calculating the option value.

#### **5.1.4 The optimal fleet composition**

We will now look at what makes a vessel attractive in the offshore supply market, and how different vessel specifications impact the likelihood that a vessel will be laid up. We will first

look at how the shipowners define efficiency for their fleet. Then we will take a closer look at sailing capability and capacity.

### *Efficiency*

Havila pointed out that there are several ways to measure a ship's efficiency. For PSVs, the easiest way would be to say that the ship with the biggest deck area is the most efficient ship. The reason is that they can carry more and conduct more jobs. However, the smallest ships use less fuel. Nevertheless, as a rule of thumb, Havila defines the biggest vessels as the most efficient ones. This same applies for AHTSs.

Age is also a consideration for a ship's efficiency. An example of this is Havila Faith that is going into lay-up from Brazil. It has a bigger deck area than Havila's other PSVs in the spot market, but it is out of the question to put it in the spot market because it is not modern enough. Because of the oversupply of vessels, there are small price differences between old and new vessels, and customers will often prefer to hire the more modern ships when the price difference is low. Havila has laid up their oldest and smallest anchor handlers but have made a trade-off between age and size for the PSVs. They have, by their definition, laid up the least efficient ships.

REM also defines a ship's efficiency by its capacity and its age. A ship has to pass a class survey every fifth year. This means that the ship has to fulfill certain requirements to stay in the class it was in. As the ship gets older it gets more expensive to keep the ship in class due to increasing maintenance costs. In addition, according to REM the size that was optimal 15 years ago is no longer optimal. For REM, the smallest ships are often the oldest ones, and these are the ones they put in lay-up first.

Volstad highlights that in their view, redundancy contributes to efficiency. An example of this would be a vessel with several engines. If one of them breaks down, they can safely operate with the other engines. Furthermore, diesel electric engines improve the fuel utilization and thereby increase the efficiency of a ship. They agree with REM's reasoning about the ship's age and capacity as one of the drivers for efficiency, where the newest and biggest vessels are more efficient. Additionally they think that the ability to handle rough weather conditions is essential to be efficient.

### *Sailing capability*

A ship's sailing capability is crucial for its ability to handle rough weather. There are several factors that contribute to handling bad weather, such as the hull design and machine power of a vessel. Shipowner2 points out that the foredecks on newer vessels have a different bow design than older ones. They have been built to sail better through the sea, being better at keeping a specified position, and being able to sail during bad weather without negatively affecting fuel efficiency. This would imply that older vessels should be more predisposed to lay-up.

The engine power also affects sailing capability, especially when the ship needs to hold its position next to the oil platforms. There is a trade-off between more powerful equipment and costs.

Previously, strong sailing capabilities have been in high demand, but in the market today the customers are less willing to pay for these extra specifications. The shipowners get a small premium for having better sailing capability, especially under rough weather conditions where other ships struggle to operate, but the premium is not enough to cover the costs.

The implication for which vessels are more likely to be laid up is ambiguous. On the one hand, strong sailing capabilities is costly, which increases the likelihood of lay-up. On the other hand, customers will prefer a vessel with better sailing capability if the price difference is low, which is what we see today.

As mentioned in the literature review, shipowners in other shipping segments may choose to slow steam their ships if demand is low. By increasing sailing time, they reduce supply and save fuel costs. However, the respondents state that slow steaming is not relevant in offshore supply shipping, because obligations to customers are usually time sensitive. Havila explains: "In this business, you have to sail with the speed the customers tells you to. You can't just slow steam and say you're not in a hurry. We'd struggle to get new contracts if we did that."

### *Capacity*

A ship's capacity can determine whether the ship is able to compete for a contract or not. We have found that the shipowners have quite different assessments of what an attractive fleet is in terms of vessel capacity.

According to DOF and Shipowner1, the optimal capacity is dependent on the customer's demand. As an example, Shipowner1 mentions that in the southern part of the North Sea there is a demand for smaller vessels, whereas in the northern part, bigger tonnage is more sought after. When facing different customer demands, Taillard (1999) suggests that the shipowners should keep a heterogeneous fleet. DOF confirms that this has been their approach. They focus on looking for jobs for their existing tonnage in other parts of the world rather than laying up ships with unfavorably large or small capacity.

Contrary to DOF, Volstad and World Wide Supply have a homogenous fleet where all their respective PSVs have the same deck area and deadweight tonnage. Volstad built all their ships with big loading capacity and the same specifications to be attractive for long-term contracts. Remøy Management states on behalf of World Wide Supply that homogeneity allows them to replace a ship that is on contract with another vessel if needed.

REM defines vessels with a big deck area as the most attractive ships in the North Sea region. They add that the problem in the market today is that there are too many large PSVs, which means that they still have to take this type of vessel out of the market even though it is the most sought after kind of tonnage.

Havila has the same view on the optimal size as REM, and wants the newest and biggest ships to stay in the market. They add that you are more likely to get favored by charterers by having a bigger deck area. Therefore, they lay up the smallest ships to be able to offer the biggest and, by their definition, the most attractive ships to the customers.

The indication for lay-up is not entirely clear, but there seems to be an inclination toward larger vessels being more attractive in the North Sea. We would therefore expect older and smaller vessels to be overrepresented in the lay-up statistics.

### **5.1.5 Uncertainty and changes in the industry**

The rapid deterioration of market conditions has led to increased uncertainty. Shipowners do not know when the recovery phase will begin, and with a high debt burden the pressure for finding new jobs for their ships is big. Because crew costs make up a significant part of the operating costs (approximately 2/3), the respondents are looking at ways to reduce this cost. By reflagging, shipowners can hire cheaper crew. If shipowners succeed in lowering their operating expenses, the day rate level where ships will be laid up, will be lower in the future.

Havila adds that they have also been met with an expectation from customers to renegotiate their existing contracts. Even though these contracts are not expiring, the customers, such as oil companies, want them to reduce their rates since they get paid less as well. This contributes to put further pressure on the already low margins for the shipowners.

Due to the overcapacity of ships, the through phase will most likely be long. All the shipowners therefore anticipate consolidations and bankruptcies. As Volstad points out, this is typically what happens when many firms enter an attractive market, and at some point the players have to change the way they operate. With fewer and larger shipowners, it will be easier for the remaining players to exert supplier power and positively impact day rates.

Havila adds that if the market will stay at this all-time low for a long time, they think that Norwegian companies will no longer be able to compete with international rivals. They anticipate that the Norwegian shipowners will have to enter into the market of very specialized vessels to find a niche that they can operate in with good margins.

Normally, one would expect to see bankruptcies during a downturn. This would lead to fewer and bigger players, which could help the industry long term. Atlantic Offshore sold most of their assets and filed for bankruptcy on April 15<sup>th</sup> 2016 (Atlantic Offshore AS, 2016). This is the only bankruptcy that has been seen among the Norwegian shipowners so far, despite several companies breaching the terms of their outstanding debt. When World Wide Supply neglected to uphold their loan agreements, the creditors decided to purchase the outstanding stocks at a deep discount. This was because they anticipated that values would be lost in a bankruptcy. Partly because a distress sale of vessels would give inadequate returns, and partly because bankruptcy is reason for termination of existing contracts.

It is clear that the shipowners would like to have more supplier power when it comes to day rates, and the idea of a management pool has been up for discussion. As Shipowner2 said, pools are typically something that is established during a through phase and liquidated during the growth phase. A management pool is “a collection of similar vessel types under various ownerships placed under the care of an administration” (Packard, 1995, p. 3). The management markets the individual vessels of the pool’s members as a unit. The goal of the pool is to increase the earnings for its members. The pool’s earnings are divided between the shipowners by a system that weights the incomes so that each member gets their fair share

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(Packard, 1995). A management pool would be a way of formalizing the tacit collusion that the shipowners report to engage in when coordinating efforts to lay up ships to limit supply.

However, even though a pool might be a solution for stabilizing the market, all the respondents agree that there are too many small players for it to be possible to implement such a pool. The free rider effect would be an issue, with shipowners not involved with a pool benefiting from increased day rates without having to agree to the terms of the pool.

Moreover, different shipowners have different specifications on their vessels, and firms are able to obtain a premium for specialized vessels in a good market. Some companies have advanced ships whereas others only operate with standardized ships. This would complicate how the profit should be shared between the shipowners. The fact that some customers only want certain ships further complicates this problem. Additionally, it is hard to make such an agreement work without entering a grey zone with the Competition Authority.

Overall, we see that the downturn has significantly increased uncertainty for the shipowners' future. If the downward pressure on day rates continue, they expect the industry to undergo significant changes. Most likely we will see fewer and larger players, but the timing and effect of these changes is difficult to predict.

### **5.1.6 Hypotheses for empirical testing**

From the qualitative analysis, we found that shipowners see the lower day rates as the main reason for laying up ships. We formed an expectation that day rates can be used to predict lay-up levels. Higher volatility in day rates seems to make the shipowners delay lay-up, so we expect volatility to be negatively correlated with lay-up. We have seen that newer vessels seem to be less likely to be laid up, and the same goes for larger vessels with higher capacity because these characteristics are positively related to efficiency. Based on these findings, we formulate the following hypotheses that we will test empirically in the next section:

- Hypothesis 1: Day rates can be used to predict lay-up levels
- Hypothesis 2: Higher volatility in day rates leads to lower lay-up levels
- Hypothesis 3: The following characteristics will make a vessel less likely to be laid up
  - Low age
  - High capacity

## 5.2 Empirical analysis

We have used OLS to test hypothesis 1 and 2. This is presented in section 5.2.1. We have used logit to test hypothesis 3. This is presented in section 5.2.2. The data sets used in the analysis were provided to us by two shipbrokers. We refer to them as Shipbroker1 and Shipbroker2 because they wish to remain anonymous.

### 5.2.1 OLS

#### *Description of data sets*

The data used in the OLS regression was made by combining two different data sets. A description of the data sets follows below.

#### **1. Fleet statistics for PSVs and AHTSs/AHTs in the North Sea region**

- Interval: Weekly, but with some minor deviations due to holidays etc.
- Relevant variables:
  - *Yard and lay-up*: Number of vessels in yard or in lay-up
  - *Spot*: Number of vessels in the spot market
  - *Yard and lay-up share*: Number of vessels in yard or in lay-up as the proportion of the total fleet in the spot market and in yard or in lay-up
- Source: Shipbroker1

#### **2. Day rates for PSVs and AHTSs/AHTs in the North Sea spot market**

- Interval: Entries were reported daily as new fixtures were made. Day rates were periodised into monthly averages starting at the observation dates in the data set with fleet statistics (week by week). Averaging the day rates has the benefit of smoothing out variation that stems from individual characteristics of the vessel and the specific contract rather than general market conditions
- Relevant variables:
  - *Day rates monthly lag $x$* : Average of new spot fixtures in NOK 10.000 starting  $x$  month prior to the observation dates in data set 1, ending  $x-1$  months prior to the observation dates (week by week), where  $x$  goes from 1 to 6
  - *Variance monthly lag $x$* : Variance of *Day rates monthly lag $x$*  where  $x$  goes from 1 to 6
- Source: Shipbroker2

As described in the industry overview, shipowners started to lay up vessels in response to the reduced offshore activity in the end of 2014. We have observations of the day rates until the end of 2015, so to get a symmetric amount of observations before and after vessels started being laid up, we use the time period August 2<sup>nd</sup> 2013 to December 31<sup>st</sup> 2015 for the OLS regressions.

Mean values and standard errors of the relevant variables are posted in table 5.3 for PSVs and table 5.4 for AHTSs.

*Table 5.3: Mean values for key variables used in the OLS regressions for PSVs. Standard errors in parantheses*

VARIABLES	2013 (from 2-Aug) PSV	2014 PSV	2015 PSV
Yard and lay-up share	8.30 % (0.00741)	12.3 % (0.00430)	32.5 % (0.0256)
Day rates monthly lag1	14.10 (1.343)	11.50 (0.256)	5.561 (0.237)
Variance monthly lag1	45.68 (8.142)	37.64 (8.406)	6.499 (0.788)

*Table 5.4: Mean values for key variables used in the OLS regressions for AHTSs. Standard errors in parantheses*

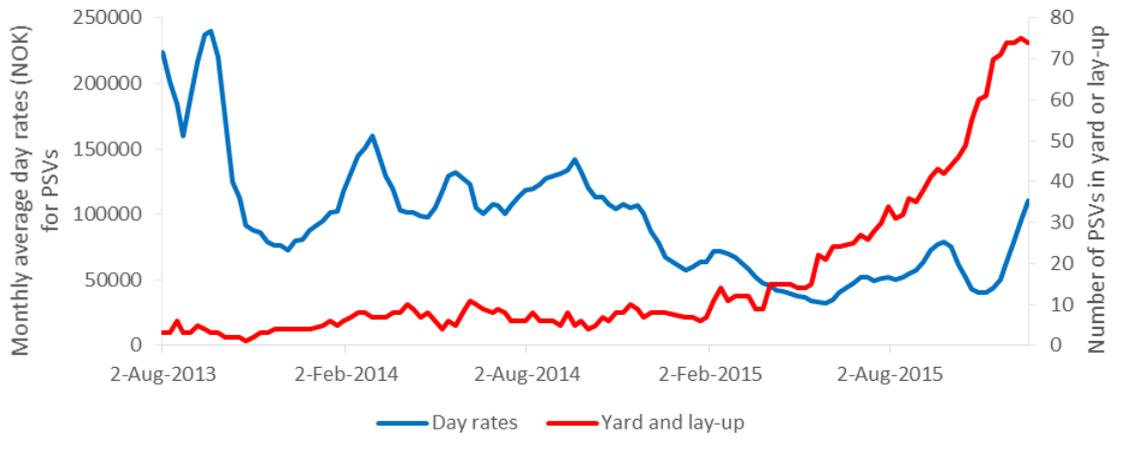
VARIABLES	2013 (from 2-Aug) AHTS	2014 AHTS	2015 AHTS
Yard and lay-up share	9.89 % (0.00291)	13.0 % (0.00963)	23.2 % (0.0126)
Day rates monthly lag1	30.35 (1.718)	35.68 (2.686)	16.87 (1.071)
Variance monthly lag1	320.3 (35.26)	604.7 (98.48)	130.9 (24.10)

### **Day rates**

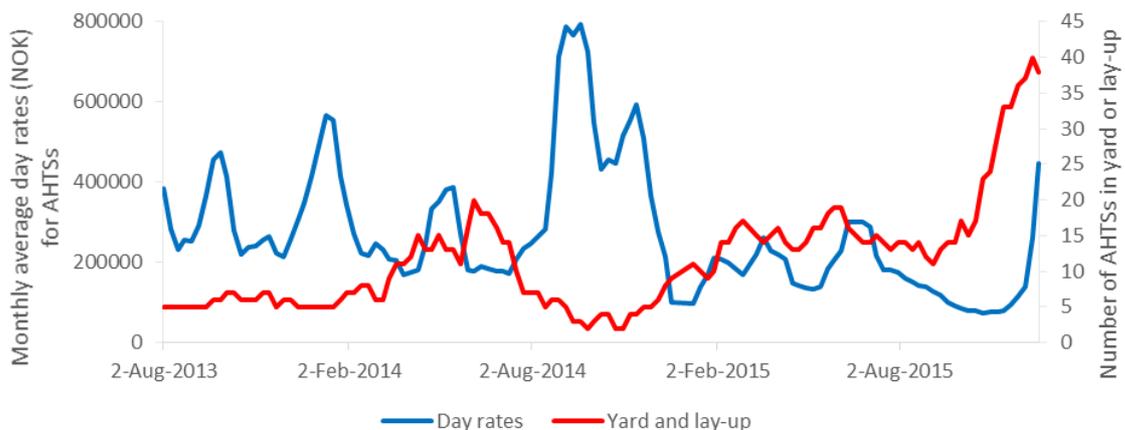
We will now look at hypothesis 1: Day rates can be used to predict lay-up levels.

As we saw in section 5.1.2, the respondents in the interviews reported that the main reason for laying up a ship is if expected income falls below operating costs less lay-up costs.

Because expected income is determined by the day rates, we expected there to be a strong negative correlation between day rates and lay-up levels. Day rates and the number of vessels in yard and lay-up are graphed in figure 5.1 and figure 5.2 for PSVs and AHTSs respectively.



*Figure 5.1: Monthly average day rates and the number of vessels in yard and lay-up over time for the PSV fleet (Shipbroker1 and Shipbroker2)*



*Figure 5.2: Monthly average day rates and the number of vessels in yard and lay-up over time for the AHTS fleet (Shipbroker1 and Shipbroker2)*

Table 5.5 and table 5.6 shows the OLS regressions for lay-up levels explained by day rates for PSVs and AHTSs respectively. The dependent variable is the number of vessels in yard and lay-up, as a proportion of the total number of vessels in the spot market and in yard and lay-up for each of the two vessel types and can be expressed as:

$$\text{Yard and lay-up share} = \frac{\text{Yard and lay-up}}{\text{Spot} + \text{Yard and lay-up}}$$

Strictly speaking, we are not interested in the number of vessels in yard, but because we were not able to find reliable data exclusively with lay-up numbers, we found it necessary to use the combined measure of vessels laid up or in yard as our dependent variable. Because vessels are in yard only for a limited time, but in lay up for longer period, this dependent variable is likely more volatile than the true number of vessels in lay-up. This increased volatility in the dependent variable may have resulted in weaker correlation than we would have found if the data excluded the number of vessels in yard.

The independent variables are the monthly average spot day rates in the months preceding the observation, with different time lags. In the first model titled (1) *Yard and lay-up share PSV*, the independent variable is *Day rates monthly lag1*, which consist of the average of the fixtures made from one month prior to the observation date, up to the observation date. In the second model, (2) *Yard and lay-up share PSV*, the day rates are lagged an additional month, so it consists of the average of fixtures made from two months prior to the observation date, up to one month prior to the observation date. Similarly, the models (3) to (6) each have an additional month of lag in the average day rates. The models for AHTSs in table 5.6 are set up in the same way.

Note that the vessels in yard and lay-up can come from both the spot and the term market, while the lagged monthly average day rates are based solely on new fixtures in the spot market. We assume that if a ship comes off a term contract, the shipowner will consider putting the ship in the spot market as an alternative to putting it in lay-up. So even if the ship has previously been in the term market, it is the level of the spot day rates that determines if lay-up is a more preferable alternative.

In addition to the day rates, we have used time dummies for the month and year the observation was made, to capture seasonal effects. The base month is January, and the base year is 2013. The regression equation for model (1) can be expressed as:

$$\text{Yard and lay-up share} = \text{Constant} + \text{Day rates monthly lag1} + \text{Month} + \text{Year} + \varepsilon$$

In the other models, *Day rates monthly lag1* will be replaced with the appropriate lagged day rate, e.g. *Day rates monthly lag2* for model (2).

*Table 5.5: The share of PSVs in yard and lay-up explained by monthly average day rates (in NOK 10.000) for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share PSV	(2) Yard and lay-up share PSV	(3) Yard and lay-up share PSV	(4) Yard and lay-up share PSV	(5) Yard and lay-up share PSV	(6) Yard and lay-up share PSV
Day rates monthly lag1	0.0163*** (0.00331)					
Day rates monthly lag2		0.00478 (0.00405)				
Day rates monthly lag3			-0.00927** (0.00388)			
Day rates monthly lag4				-0.0226*** (0.00354)		
Day rates monthly lag5					-0.0193*** (0.00345)	
Day rates monthly lag6						-0.0174*** (0.00323)
2.Month	0.00276 (0.0420)	0.0422 (0.0453)	0.0311 (0.0447)	0.0116 (0.0390)	-0.0882* (0.0466)	0.0992** (0.0416)
3.Month	0.0310 (0.0426)	0.0264 (0.0486)	0.0321 (0.0461)	-0.0367 (0.0419)	-0.141*** (0.0528)	-0.0362 (0.0442)
4.Month	0.0743* (0.0413)	0.0472 (0.0458)	0.0692 (0.0448)	-0.00699 (0.0399)	-0.145*** (0.0538)	-0.0479 (0.0446)
5.Month	0.0673* (0.0390)	0.0636 (0.0430)	0.0614 (0.0421)	0.0594 (0.0367)	-0.133** (0.0514)	-0.0707 (0.0453)
6.Month	0.164*** (0.0426)	0.150*** (0.0469)	0.133*** (0.0467)	0.119*** (0.0404)	0.0119 (0.0485)	0.0268 (0.0478)
7.Month	0.158*** (0.0400)	0.152*** (0.0440)	0.138*** (0.0435)	0.0677* (0.0399)	-0.0221 (0.0499)	0.0683 (0.0421)
8.Month	0.152*** (0.0380)	0.182*** (0.0416)	0.172*** (0.0409)	0.0942** (0.0382)	-0.0516 (0.0565)	0.0575 (0.0440)
9.Month	0.126*** (0.0410)	0.190*** (0.0427)	0.196*** (0.0413)	0.115*** (0.0383)	-0.0132 (0.0532)	0.0429 (0.0473)
10.Month	0.200*** (0.0370)	0.177*** (0.0434)	0.195*** (0.0399)	0.148*** (0.0356)	-0.0104 (0.0515)	0.0637 (0.0436)
11.Month	0.287*** (0.0388)	0.250*** (0.0419)	0.269*** (0.0420)	0.212*** (0.0361)	0.0810* (0.0473)	0.122*** (0.0437)
12.Month	0.290*** (0.0405)	0.271*** (0.0459)	0.228*** (0.0447)	0.275*** (0.0377)	0.0917* (0.0488)	0.171*** (0.0422)
2014.Year	0.167*** (0.0247)	0.151*** (0.0331)	0.0659* (0.0356)	-0.0308 (0.0330)	0.0267 (0.0288)	0.0701*** (0.0251)
2015.Year	0.464*** (0.0364)	0.380*** (0.0520)	0.217*** (0.0525)	0.0595 (0.0474)	0.129*** (0.0422)	0.182*** (0.0354)
Constant	-0.358*** (0.0583)	-0.210*** (0.0758)	0.0361 (0.0814)	0.321*** (0.0791)	0.365*** (0.0963)	0.234*** (0.0769)
Observations	120	120	120	120	120	120
R <sup>2</sup>	0.755	0.703	0.714	0.783	0.768	0.764

Standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

*Table 5.6: The share of AHTSs in yard and lay-up explained by monthly average day rates (in NOK 10.000) for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share AHTS	(2) Yard and lay-up share AHTS	(3) Yard and lay-up share AHTS	(4) Yard and lay-up share AHTS	(5) Yard and lay-up share AHTS	(6) Yard and lay-up share AHTS
Day rates monthly lag1	-0.00135*** (0.000466)					
Day rates monthly lag2		-0.00231*** (0.000422)				
Day rates monthly lag3			-0.00210*** (0.000392)			
Day rates monthly lag4				-0.000978** (0.000460)		
Day rates monthly lag5					0.000582 (0.000565)	
Day rates monthly lag6						0.000361 (0.000520)
2.Month	0.0343 (0.0306)	0.0636** (0.0279)	0.0227 (0.0282)	0.0484 (0.0308)	0.0598* (0.0335)	0.0380 (0.0341)
3.Month	0.0397 (0.0317)	0.0421 (0.0288)	0.0504* (0.0289)	0.0422 (0.0324)	0.0686* (0.0352)	0.0530 (0.0325)
4.Month	0.0582* (0.0306)	0.0626** (0.0278)	0.0421 (0.0284)	0.0679** (0.0309)	0.0925** (0.0369)	0.0700** (0.0316)
5.Month	0.0830*** (0.0289)	0.0814*** (0.0264)	0.0603** (0.0271)	0.0793*** (0.0299)	0.109*** (0.0336)	0.0961*** (0.0301)
6.Month	0.120*** (0.0317)	0.129*** (0.0287)	0.0996*** (0.0295)	0.118*** (0.0327)	0.156*** (0.0387)	0.133*** (0.0325)
7.Month	0.0429 (0.0298)	0.0562** (0.0270)	0.0300 (0.0275)	0.0405 (0.0308)	0.0784** (0.0373)	0.0605* (0.0311)
8.Month	0.0371 (0.0275)	0.0447* (0.0251)	0.0206 (0.0256)	0.0305 (0.0284)	0.0672* (0.0373)	0.0475 (0.0294)
9.Month	0.0360 (0.0286)	0.0183 (0.0258)	-0.00103 (0.0262)	0.0110 (0.0290)	0.0416 (0.0354)	0.0267 (0.0304)
10.Month	0.0357 (0.0272)	0.0751*** (0.0258)	0.0161 (0.0254)	0.0287 (0.0282)	0.0599* (0.0343)	0.0433 (0.0287)
11.Month	0.0912*** (0.0279)	0.101*** (0.0256)	0.101*** (0.0257)	0.0839*** (0.0289)	0.116*** (0.0347)	0.0986*** (0.0291)
12.Month	0.117*** (0.0294)	0.125*** (0.0270)	0.0982*** (0.0274)	0.124*** (0.0299)	0.145*** (0.0381)	0.124*** (0.0307)
2014.Year	0.0451** (0.0177)	0.0445*** (0.0158)	0.0314** (0.0158)	0.0272 (0.0176)	0.0393** (0.0189)	0.0367* (0.0188)
2015.Year	0.123*** (0.0178)	0.102*** (0.0170)	0.106*** (0.0168)	0.122*** (0.0186)	0.143*** (0.0191)	0.139*** (0.0185)
Constant	0.0765** (0.0304)	0.104*** (0.0276)	0.127*** (0.0300)	0.0793** (0.0344)	-0.00720 (0.0490)	0.0186 (0.0359)
Observations	120	120	120	120	120	120
R <sup>2</sup>	0.597	0.661	0.658	0.583	0.569	0.567

Standard errors in parentheses  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

For the PSVs in table 5.5, we see that all the day rate variables are statistically significant at the 5 or 1 percent level, with the exception of *Day rates monthly lag2*, which is not statistically significant. Furthermore, we notice that while *Day rates monthly lag3* to *6* have negative coefficients as we expected, *Day rates monthly lag1* and *2* have positive coefficients. This could indicate that there is a time lag between when the decision to lay up a ship is made, and when the lay-up is actually initiated.

The coefficients should be interpreted as the expected change in the share of the fleet that is in yard and lay-up if the monthly average day rates increases with NOK 10.000. E.g. for model (1) for the PSVs, the coefficient for *Day rates monthly lag1* is 0.0163, so we would expect the lay-up share to increase by 1.68 percentage points if day rates increased by NOK 10.000. This positive correlation is unintuitive.

A possible explanation for why the coefficients for *Day rates monthly lag1* and *Day rate monthly lag2* are positive is that the day rates are also affected by lay-up levels, not just the other way around. This means that the day rates to some degree are endogenously determined. When a ship is put in lay-up, this reduces the supply of ships. All other things equal, this leads to an increase in day rates, and thus a positive correlation between day rates and lay-up levels. However, we would expect this effect to take place after the ship has been put in lay-up, and consequently not impact our day rate variables seeing as they have a time lag. Though if a ship that is preparing for lay-up is not bid for spot contracts some time before it actually enters lay-up, this could explain why the effect is observed in the lagged variable.

When we run the regressions for the PSVs in table 5.5 with just the day rates as the independent variables and thus leave out the dummies for month and year, all the coefficients for the lagged monthly day rate variables are negative and statistically significant at the 1 percent level. This means that lower day rates are correlated with higher lay-up levels when disregarding fixed effects related to the observation's month and year. Without the dummies, the  $R^2$  is lower, ranging from 0.178 when the day rates are lagged one month, to 0.483 with six month's lag. This means that the dummies explain a significant part of the variation in day rates. The unexpected positive coefficients when the dummies were included can possibly be explained by the dummies dominating the effect of the day rates, so that it seems as though the day rates have less correlation with the lay-up levels when the dummies are included.

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For the AHTSs in table 5.6 we see that all the statistically significant coefficients for the day rates are negative. *Day rates monthly lag 5* and *6* are however positive, though not statistically significant. We see that for the statistically significant coefficients, the coefficients are larger with two to three months' time lag. This also points to a time lag between the decision to lay up a ship, and when the lay-up is initiated. When the dummies for month and year are excluded for the AHTS regression in table 5.6, we largely get the same result, where the day rate variables with 1 to 4 months lag are negative and statistically significant, while the 5 and 6 months lag are not statistically significant.

The dummies for month and year captures fixed effects that is not explained by the lagged average day rates. From table 5.5 for the PSVs, we see that in model (1) to (4), most of the monthly dummies for the months 6 to 12 are positive, and statistically significant at the 1 percent level. This indicates that vessels are more likely to be laid up towards the end of the year than in the base month January. This makes sense if shipowners expect demand to be lower during winter when challenging weather conditions leads to a reduction in offshore activity. Shipowners will then initiate lay-up when the period of higher offshore activity is coming to an end. This is in accordance with Næss' (1992) prediction that a pessimistic outlook will lead to quicker lay-up.

For the AHTSs in table 5.6, the trend is less clear, because while the dummies for the months 5, 6, 11 and 12 are statistically significant, most of the others are not. The significant coefficients are however positive, which is in line with that we see for the PSVs.

For the year dummies, we see that the coefficients that are statistically significant are positive both for PSVs and AHTSs. This means that if day rates were kept constant, a larger share of the fleet would be laid up in 2014 and 2015 than in the base year 2013. The coefficients are consistently higher for 2015 than for 2014. This could be a result of the shipowners coming to the realization that the reduction in oil price, offshore activity and consequently demand for supply vessels will last long term, and that a recovery would take several years, so that lay-up would be a more favorable alternative in the meantime.

Overall, we see that models with monthly lagged day rates and monthly and yearly dummies explain between 70.3 and 78.3 percent of the variation in yard and lay-up share for PSVs, and between 56.7 and 66.1 percent for AHTSs. We consider this explanatory power relatively high. However, we see that we get some unintuitive results for the PSVs, where

higher day rates are correlated with higher lay-up levels in one of the regressions. This makes us question the reliability of the models.

### *Volatility*

We will now look at hypothesis 2: Higher volatility in day rates leads to lower lay-up levels.

In table 5.7 and table 5.8, we have added independent variables for the lagged day rates' variance. The regression equation for model (1) can now be expressed as:

$$\text{Yard and lay-up share} = \text{Constant} + \text{Day rates monthly lag1} + \text{Variance monthly lag1} + \text{Month} + \text{Year} + \varepsilon$$

*Table 5.7: The share of PSVs in yard and lay-up explained by monthly average day rates (in NOK 10.000) and variance of the monthly average day rates for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share PSV	(2) Yard and lay-up share PSV	(3) Yard and lay-up share PSV	(4) Yard and lay-up share PSV	(5) Yard and lay-up share PSV	(6) Yard and lay-up share PSV
Day rates	0.0132***					
monthly lag1	(0.00357)					
Variance	0.000549**					
monthly lag1	(0.000262)					
Day rates		0.00446				
monthly lag2		(0.00423)				
Variance		7.42e-05				
monthly lag2		(0.000267)				
Day rates			-0.00798**			
monthly lag3			(0.00402)			
Variance			-0.000285			
monthly lag3			(0.000240)			
Day rates				-0.0217***		
monthly lag4				(0.00382)		
Variance				-0.000136		
monthly lag4				(0.000219)		
Day rates					-0.0189***	
monthly lag5					(0.00361)	
Variance					-8.90e-05	
monthly lag5					(0.000236)	
Day rates						-0.0169***
monthly lag6						(0.00335)
Variance						-0.000143
monthly lag6						(0.000233)
Month	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.343***	-0.209***	0.0204	0.307***	0.361***	0.226***
	(0.0578)	(0.0762)	(0.0823)	(0.0822)	(0.0972)	(0.0781)
Observations	120	120	120	120	120	120
R <sup>2</sup>	0.765	0.703	0.718	0.784	0.768	0.765

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

*Table 5.8: The share of AHTSs in yard and lay-up explained by monthly average day rates (in NOK 10.000) and variance of the monthly average day rates for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share AHTS	(2) Yard and lay-up share AHTS	(3) Yard and lay-up share AHTS	(4) Yard and lay-up share AHTS	(5) Yard and lay-up share AHTS	(6) Yard and lay-up share AHTS
Day rates	-0.00371***					
monthly lag1	(0.000836)					
Variance	8.04e-05***					
monthly lag1	(2.52e-05)					
Day rates		-0.00236***				
monthly lag2		(0.000831)				
Variance		2.91e-06				
monthly lag2		(2.56e-05)				
Day rates			-0.00136*			
monthly lag3			(0.000804)			
Variance			-2.58e-05			
monthly lag3			(2.55e-05)			
Day rates				-0.000263		
monthly lag4				(0.000935)		
Variance				-2.30e-05		
monthly lag4				(2.94e-05)		
Day rates					0.000411	
monthly lag5					(0.00101)	
Variance					9.75e-06	
monthly lag5					(3.40e-05)	
Day rates						7.84e-05
monthly lag6						(0.000985)
Variance						8.13e-06
monthly lag6						(2.82e-05)
Month	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.116***	0.105***	0.0993**	0.0607	-0.0109	0.0219
	(0.0315)	(0.0334)	(0.0387)	(0.0393)	(0.0508)	(0.0382)
Observations	119	119	119	119	119	119
R <sup>2</sup>	0.642	0.661	0.664	0.586	0.575	0.572

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

We see that the variances are only statistically significant for model (1), both for PSVs and AHTSs. Both of these coefficients are positive, which is not in line with the expectation that higher volatility is related to lower lay-up levels. In addition, because the day rates seem to have a stronger impact with a few months lag, we would have expected this to be the case for volatility as well, but that is not what we observe.

In table 5.9 and table 5.10, the lagged day rates have been removed, leaving lagged variance and the monthly and yearly dummies as independent variables. The regression equation for model (1) can now be expressed as:

$$\text{Yard and lay-up share} = \text{Variance monthly lag1} + \text{Month} + \text{Year} + \varepsilon$$

*Table 5.9: The share of PSVs in yard and lay-up explained by the variance of the monthly average day rates for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share PSV	(2) Yard and lay-up share PSV	(3) Yard and lay-up share PSV	(4) Yard and lay-up share PSV	(5) Yard and lay-up share PSV	(6) Yard and lay-up share PSV
Variance monthly lag1	0.000945*** (0.000253)					
Variance monthly lag2		0.000151 (0.000257)				
Variance monthly lag3			-0.000413* (0.000234)			
Variance monthly lag4				-0.000597** (0.000232)		
Variance monthly lag5					-0.000432* (0.000254)	
Variance monthly lag6						-0.000450* (0.000250)
Month	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.179*** (0.0398)	-0.143*** (0.0427)	-0.123*** (0.0402)	-0.114*** (0.0398)	-0.106** (0.0431)	-0.123*** (0.0402)
Observations	120	120	120	120	120	120
R <sup>2</sup>	0.734	0.700	0.707	0.717	0.707	0.708

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

*Table 5.10: The share of AHTSs in yard and lay-up explained by the variance of the monthly average day rates for the 1-6 months preceding the observation, with dummies for the month and year the observation was made*

VARIABLES	(1) Yard and lay-up share AHTS	(2) Yard and lay-up share AHTS	(3) Yard and lay-up share AHTS	(4) Yard and lay-up share AHTS	(5) Yard and lay-up share AHTS	(6) Yard and lay-up share AHTS
Variance monthly lag1	-1.40e-05 (1.46e-05)					
Variance monthly lag2		-5.92e-05*** (1.38e-05)				
Variance monthly lag3			-6.35e-05*** (1.26e-05)			
Variance monthly lag4				-3.01e-05** (1.50e-05)		
Variance monthly lag5					2.12e-05 (1.91e-05)	
Variance monthly lag6						1.00e-05 (1.49e-05)
Month	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.0373 (0.0282)	0.0414 (0.0257)	0.0490* (0.0251)	0.0533* (0.0292)	0.00255 (0.0384)	0.0237 (0.0305)
Observations	119	119	119	119	119	119
R <sup>2</sup>	0.573	0.635	0.654	0.586	0.575	0.572

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

We see that the *Variance monthly lag1* is still positive and statistically significant for the PSVs in table 5.9. However, we see that in the models (3) to (6), the lagged variances are now statistically significant and negative. The significant coefficients in the AHTS models in table 5.10 are also negative. This is in line with our expectation that higher volatility leads to lower lay-up levels.

The presence of both positive and negative coefficients means that we cannot draw the conclusion that higher volatility leads to lower lay-up levels.

## 5.2.2 Logit

We will now look at hypothesis 3: The following characteristics will make a vessel less likely to be laid up

- Low age
- High capacity

### *Description of data set*

The following data set was used for the logistic regression:

#### **Overview of vessels in northwestern Europe**

- Date: February 8<sup>th</sup> 2016
- Relevant variables:
  - *Laid up*: Dummy variable for whether or not the vessel is laid up
  - *Clear deck area*: Deck area available for cargo in square meters. Only applicable for PSVs
  - *Year in service*: The year in which the vessel was put in service
  - *Deadweight tonnage*: The total mass the vessel can carry in tons
  - *DP*: Dummy for the ship's class of dynamic positioning system, which is an automatic system to control a vessel's position (the dummy is 1 if the ship has DP class 1, and 2 if it has DP class 2. The base case is no DP)
  - *Length over all*: Length of the vessel's hull in meters
  - *Brake horsepower*: A measure of the engine's efficiency
  - *Bollard pull*: Maximal pulling power or force that can be exerted by the vessel. Only applicable for AHTSs
- Source: Shipbroker2

Note that as in the OLS model, we assume that shipowners will consider the spot market as the alternative to putting a ship in lay-up. Consequently we compare the laid up vessels with the vessels in the spot market, even though some vessels are laid up directly from the term market when a contract ends.

Mean values and standard errors of key variables are posted in table 5.11.

*Table 5.11: Mean values for the variables used in the logit regressions for PSVs and AHTSs. Standard errors in parantheses*

VARIABLES	PSV	AHTS
Clear deck area	848.5 (17.67)	
Year in service	2007 (0.710)	2004 (1.103)
Deadweight tonnage	4,079 (78.40)	3,265 (153.2)
Length overall	81.63 (0.965)	79.73 (1.499)
Break horsepower	7,817 (210.7)	18,841 (900.7)
Bollard pull		211.0 (9.198)

### *Vessel characteristics*

Table 5.12 shows the output from the logit model for PSVs, and table 5.13 does the same for AHTSs. Each column describes a variation of the model, and going from left to right, the variable with the least statistically significant coefficient was removed until only coefficients that were statistically significant at the 5 percent level remained in the model. Each coefficient indicates the independent variables' impact on the likelihood that a given vessel will be laid up. The regression equation for model (1) for the PSVs can be expressed as:

$$\textit{Laid up} = \textit{Constant} + \textit{Clear deck area} + \textit{Year in service} + \textit{Deadweight tonnage} + \textit{DP} + \textit{Length overall} + \textit{Break horsepower}$$

And the regression equation for model (1) for the AHTS can be expressed as:

$$\textit{Laid up} = \textit{Constant} + \textit{Length overall} + \textit{Bollard pull} + \textit{Year in service} + \textit{Break horsepower} + \textit{DP} + \textit{Deadweighth tonnage}$$

*Table 5.12: The likelihood of a PSV being laid up explained by vessel characteristics*

VARIABLES	(1) Laid up PSV	(2) Laid up PSV	(3) Laid up PSV	(4) Laid up PSV	(5) Laid up PSV	(6) Laid up PSV
Clear deck area	-0.00216 (0.00215)	-0.00216 (0.00214)	-0.00264 (0.00185)	-0.00260 (0.00181)	-0.00348*** (0.00128)	-0.00377*** (0.00128)
Year in service	-0.0623* (0.0364)	-0.0627* (0.0363)	-0.0628* (0.0364)	-0.0527 (0.0321)	-0.0562* (0.0309)	
Deadweight tonnage	-0.000237 (0.000409)	-0.000222 (0.000395)	-0.000262 (0.000379)	-0.000233 (0.000373)		
1.DP	0.520 (1.141)	0.529 (1.139)	0.590 (1.126)			
2.DP	0.646 (1.029)	0.657 (1.026)	0.657 (1.025)			
Length over all	-0.0194 (0.0486)	-0.0171 (0.0452)				
Break horsepower	1.82e-05 (0.000118)					
Constant	129.3* (72.70)	130.0* (72.62)	129.3* (72.68)	109.4* (64.27)	116.4* (61.90)	3.715*** (1.137)
Observations	119	119	119	119	119	119
Pseudo R <sup>2</sup>	0.097	0.097	0.096	0.094	0.091	0.067

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

*Table 5.13: The likelihood of an AHTS being laid up explained by vessel characteristics*

VARIABLES	(1) Laid up AHTS	(2) Laid up AHTS	(3) Laid up AHTS	(4) Laid up AHTS	(5) Laid up AHTS
Length over all	0.0673 (0.0523)	0.0759* (0.0429)	0.0802* (0.0417)	0.0890** (0.0405)	0.0891** (0.0403)
Bollard pull	-0.0248* (0.0128)	-0.0240* (0.0125)	-0.0224* (0.0121)	-0.0141** (0.00668)	-0.0159** (0.00660)
Year in service	-0.0382 (0.0304)	-0.0373 (0.0303)	-0.0315 (0.0289)	-0.0269 (0.0281)	
Break horsepower	0.000114 (0.000127)	0.000114 (0.000127)	0.000104 (0.000123)		
1.DP	0.529 (1.111)	0.593 (1.090)			
2.DP	0.432 (0.929)	0.481 (0.916)			
Deadweight tonnage	0.000150 (0.000535)				
Constant	73.23 (60.82)	71.10 (60.49)	59.35 (57.58)	49.56 (55.81)	-3.880* (2.071)
Observations	83	83	83	83	83
Pseudo R <sup>2</sup>	0.077	0.076	0.073	0.066	0.058

Standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

In model (1) in table 5.12, we see that only *Year in service* is statistically significant. *Clear deck area* becomes statistically significant in model (5), and we suspect that it is not statistically significant in the models (1) to (4) because of the presence of multicollinearity. Multicollinearity is a result of high correlation between two or more of the independent variables. In the PSV-models, *Clear deck area*, *Deadweight tonnage* and *Length overall* show signs of multicollinearity, which is unsurprising as they all relate to the size of the ship. Because larger vessels generally require more powerful engines, these measures are also likely to have some correlation with *Break horsepower*, though to a lesser extent than with each other.

In the AHTS-models *Break horsepower* and *Bollard pull* show signs of multicollinearity, as well as *Deadweight tonnage* and *Length overall*. In both models, *Year in service* and *DP* might be correlated with each other because newer vessels are more likely to have more sophisticated technological equipment.

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The presence of multicollinearity is a violation of the assumptions for logistic regression. Multicollinearity makes each individual coefficient unreliable, but does not compromise the reliability of the model itself. When going from left to right in table 5.12 and table 5.13, we see that the pseudo  $R^2$  decreases in small increments as variables are removed from the model. This indicates that little information is lost when these strongly non-significant variables are removed, which is typical when multicollinearity is present.

### **Age**

As can be seen from table 5.12 and table 5.13, the variable *Year in service* has a negative coefficient for both PSVs and AHTSs. The variable reports the year which the vessel was put in service, so the negative coefficient should be interpreted as newer vessels being less likely to be laid up. This is in accordance with our hypothesis. However, only a few the coefficients are statistically significant, so the link between vessel age and the likelihood of lay-up does not seem to be strong.

In the qualitative analysis, we saw that some newbuilds go directly into lay-up without entering the market first. We would expect newbuilds to be more efficient due to technological progress, but the cost of making a newbuild fully operational when it is done at the shipyard makes them predisposed to be laid up immediately. This could weaken the correlation between age and the likelihood of lay-up.

### **Capacity**

The variables related to carrying capacity for PSVs are *Clear deck area*, *Deadweight tonnage* and *Length overall*. In the PSV regressions in table 5.12, all these three variables have negative coefficients. This is in accordance with our hypothesis. *Clear deck area* is the only variable that is statistically significant, and it is only significant in the regressions (5) and (6). This indicates that among the variables that measure carrying capacity, clear deck area is the most relevant to predict lay-up. This makes sense, given that clear deck area is the criteria usually used to distinguish between large and small PSVs.

In the regressions for AHTSs in table 5.13, *Bollard pull* and *Length overall* are the only two statistically significant variables, and they are significant only in the regressions (4) and (5). Bollard pull (BP) is a measure of a vessel's pulling power. None of the respondents in the interviews mentioned BP specifically as a measure of capacity, though we would expect that higher BP contributes positively to the capacity of an AHTS. In simple terms, higher BP

translates to a stronger vessel, though several other factors contribute to the ship's ability to perform demanding operations. We would expect that higher BP increases a ship's efficiency, and thereby reduces the likelihood of lay-up. This is exactly what we observe in the regression, represented with a negative coefficient for BP.

The *Length overall* coefficient for AHTSs is positive, meaning that a larger vessel would be more likely to be laid up. Some of the shipowners mentioned that they consider larger AHTSs to be more efficient. In light of that, the result we have found here is surprising. Though we have seen that larger size is associated with some disadvantages such as higher fuel consumption. That could explain why we have found that larger AHTSs are more likely to be laid up.

Overall, we see that high capacity as measured by *Clear deck area* for PSVs and *Bollard pull* for AHTSs reduces the likelihood of lay-up, which is in line with our hypothesis.

### ***Sailing capability***

Based on the interviews, we found that strong sailing capability and particularly the ability to withstand rough weather conditions contributes positively to efficiency. But we also found that there is a tradeoff with costs, so the implication for lay-up was ambiguous. Among the variables we used in the regressions, we expected both *Break horsepower* (BHP) and *DP class* to be relevant measures for sailing capability, though sailing capability is complex and depends on other factors such as hull design and size of the vessel as well. For both the PSVs in table 5.12 and the AHTSs in table 5.13 we see that neither BHP nor DP is statistically significant in any of the models, so we cannot conclude that these variables have an impact on the likelihood that a vessel will be laid up.

### ***Suggested improvements of the model***

During the interviews, several other factors that are not included in our regression models were mentioned by the respondents as determinants that increases the likelihood of lay-up for a specific vessel. Because we were restricted by data availability, we were not able to include measures for these factors.

Several of the respondents mentioned that if a ship is due to have extensive maintenance performed or class surveys, it is more likely to be laid up than a similar vessel that does not have to carry out these procedures in the near future. Factors that contribute to high

operating cost will increase the likelihood of layup. Crew costs make up around 2/3 of the total operating costs for a given vessel, so a ship that requires a larger crew requires higher day rates to remain profitable, all else being equal. We expect that the models could be improved by including variables that incorporate these factors.

In addition, our sample sizes are limited with 119 observations for the PSVs and 83 observations for the AHTSs. Increasing the sample size, e.g. by including other geographic regions than the North Sea would probably improve the reliability of the models, though we expect that there are regional differences with regard to which vessels are more attractive to keep in the market.

In our logit models, we only take into consideration whether or not a ship is laid up, not when it was put in lay-up. We expect less efficient vessels to be laid up first, so by including the time of when a ship is laid up, we would expect to see a stronger correlation between the relevant measures of efficiency and the likelihood that a vessel is laid up.

In addition, we know that some shipowners such as Volstad and World Wide Supply have homogenous fleets. When these shipowners decide to lay-up ships, they cannot choose between ships with different specifications. If the model factored in whether or not the shipowner had different options for which type of vessels to lay-up, we would expect there to be a clearer trend in how vessel specifications affect the likelihood of lay-up.

## 6. Conclusion

Through our qualitative analysis, we documented that shipowners have a dual motivation when deciding to put ships in lay-up: To reduce costs and to improve day rates by reducing supply. They achieve this by coordinating lay-up levels and thus engage in tacit collusion.

We have also seen that even though there is an expectation between shipowners that each should contribute to reducing supply by putting a part of their fleet in lay-up, it is common to still offer the laid up vessels for term contracts. This means that supply is not necessarily reduced overall, but rather shifted from the spot market to the term market.

The respondents agree that there are economies of scale in lay-up, meaning that the average costs of having a ship in lay-up declines with the number of ships the shipowner has in lay-up. This indicates that shipowners that already have a ship in lay-up will be more inclined to put additional ships in lay-up, provided that they are able to co-locate the laid up vessels.

The direct costs associated with going into lay-up are low, but the costs of going out of lay-up may be high depending on how long the lay-up period has lasted. The costs of going out of lay-up may serve as an indirect cost of entering lay-up, because these costs may make customers more reluctant to award a contract to a ship that is in lay-up. This in and of itself reduces the attractiveness of lay-up. But the opportunity to postpone maintenance costs makes lay-up more attractive.

Through the interviews and the available literature, we formed an expectation that both day rates and variance in the day rates are negatively correlated with lay-up. In the empirical analysis, we have shown that the day rates do in fact negatively correlate with lay-up, but that there might be a time lag in how a reduction in day rates leads to an increase in laid up vessels. We have not been able to show that higher variance leads to lower lay-up levels.

We also expected that low age and high carrying capacity would reduce the likelihood that a given vessel would be put in lay-up. In the empirical analysis, we have shown that vessel age does seem to have some negative correlation with lay-up levels, though the correlation was not strong. Capacity as measured by clear deck area had a significant, negative correlation with the likelihood of lay-up for PSVs, while bollard pull had a significant, negative correlation with the likelihood of lay-up for AHTSs.

## **Appendix A: Invitation to participate in interview**

Subject: Interview in relation to master thesis

Hi,

In relation to our master thesis in Economics and Business Administration at the Norwegian School of Economics we are conducting interviews of relevant players in the offshore supply shipping industry. On that occasion we would like to ask for your participation.

The thesis concerns how offshore supply shipowners adjust to the oil price drop, specifically with regard to the decision to lay up ships. The purpose of the interviews is to map how the industry players analyze the new market conditions and how the lay-up decision is made. We think the result will be interesting for you.

Preferably we wish to conduct the interview in week xx at your premises, but we are flexible. The interview will last approximately an hour. Feel free to contact us if you have any questions.

We look forward to your reply.

Best regards,

Maria Tomren and Lovise Vik Grøvdal

## Appendix B: Interview questions

### General

1. How is it different to operate in the market today compared to two years ago?
  - a. What measures are you taking to stay competitive in the market today?
2. Do you think there is a lasting shift in the market, or is this a short-term through phase?
3. How do you think the industry will change if the day rates stay at the low level they are at today?

### Lay-up levels

4. When was the first time you considered laying up ships?
5. Could you walk us through the analysis you made when deciding whether to lay up the vessels you currently have in lay-up?
  - a. What was crucial (pulled the trigger) when you laid up your first ship?
6. What is your role in the lay-up decision?
7. Can you list the important factors for deciding to lay up a vessel?
8. How much does temporary lay-off regulations affect your flexibility to lay up a ship?
  - a. How does laying up ships and laying off experienced crew impact your ability to do well during the upturn when and if demand increases?
9. How would you characterize the likelihood for your company to lay up additional vessels? What events could trigger such a response?
10. How costly is it to put a ship in lay up?
11. What are the costs incurred when in lay-up and what expenses are saved compared to keeping the ship active?
  - a. Are there economies of scale in laying up a vessel?
12. Under what circumstances will you return the laid up ships to the market?
13. What costs will be incurred when pulling a ship from lay-up?
14. How do you decide which is the preferable alternative between laying up, scrapping and selling vessels?

### The lay-up decision

15. Do you first decide that a part of the fleet is to be laid up and then decide which specific ship to lay up, or do you first look at the specific ship?

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- a. How does deciding which vessel to lay up differ between AHTSs and PSVs?
16. What are the criteria you use to evaluate whether to put a ship in lay-up? Costs, size, efficiency, ship age, number of employees etc.
    - a. Which one has the biggest impact on the decision?
    - b. Are there any considerations that have such a big impact that it can keep a ship from lay-up? In that case, which are these?
    - c. Are there common traits between the ships you have decided to lay up? Which?
  17. What determines how efficient a ship is in the offshore supply industry? [Is this effectiveness constant or can it change with market conditions?]
  18. Why does some newbuilds go directly into lay-up without entering the market first?
  19. From your point of view, do different shipowners make different considerations for the vessels they decide to lay up?

### **Signaling effects**

20. We've assumed that the motivation to lay up a vessel is partly to save costs and partly to reduce supply with the hope of increasing day rates to benefit the remaining fleet. Is this a fair assumption?
  - a. How important are the two goals relative to each other?
  - b. Is there a signaling effect to other players when laying up ships? Explain.
21. Is there an expectation between shipowners that each should contribute to reduce supply? Explain.
  - a. How is this made difficult by the globalization of operations (e.g. will a reduction in supply by Norwegian shipowners be substituted with an influx of foreign vessels?)
22. We have heard some talk about creating a management pool between some Norwegian shipowners in order to increase competitiveness. Could you tell us more about this?

### **Concluding remarks**

23. Is there anything you would like to add?

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