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A Logit Model for the Lay-Up Decision in the North Sea Offshore Rig Market

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Abstract

The thesis examines the lay-up decision in the North Sea offshore rig market from 2010 through march 2017. Using empirical analysis, we have specified a logistic regression model to investigate how rig characteristics, firm size and market variables affect the decision to both cold- and ready-stack a jackup or a semi-submersible rig.

We find that that younger jackups with deep *water depth* owned by companies with multiple rigs in the North Sea, are less likely to be laid up. In a period with varying market conditions, a higher value of the rig characteristics *variable deck load*, *quarters capacity* and *blow out preventer (BOP),* as well as the specification *severe environment*, increase the probability of laying up a jackup.

For semi-submersibles, we find that younger rigs with a higher value of *max water depth* and *quarters capacity*, equipped with *self-propulsion*, *DP-3* system and classified for *severe environment*, were less likely to be laid up. While a higher value of *variable deck load* increased the likelihood of cold-stacking a semi-submersible.

The regression results show that a higher *day rate* and expectations for a higher future *oil price* strongly decrease the likelihood for both jackups and semi-submersibles being laid up.

The thesis supplements the existing literature of the offshore rig market. To our knowledge, no economical investigation regarding the lay-up decision have been carried out on the North Sea offshore rig market. This thesis therefore provides a basis for further research of this market. We hope the findings will be of interest for drilling operators when deciding which rig to send into lay-up. In addition, the findings may be of interest for brokers and banks when evaluating rig companies.

Preface

This thesis is written as a part of our Master of Science in Economics and Business Administration at NHH - Norwegian School of Economics, within our major Energy, Natural Resources and the Environment.

The summer of 2014 was the start of the downturn in the oil industry which affected the offshore rig market in the upcoming years. As the oil price decreased, so did the utilization rates in the North Sea offshore rig market. Lower utilization rates led to a higher number of laid up rigs, both cold- and ready-stacked. We started our master's degree at NHH in 2015, and the downturn in the oil industry have been discussed in most of our courses. This has triggered our curiosity and motivated us to explore and gain deeper knowledge of the industry.

We would like to thank Harrison M. Alger for introducing us to Wendy A. DiBenedetto and RigLogix. Granting us access to RigLogix gave us the opportunity to build detailed datasets regarding rigs operating in the North Sea, and for that we are forever grateful. In addition, we would like to thank RigZone's analyst, Teresa Wilkie, for providing advice regarding rig characteristics and specifications.

Lastly, we would specially like to thank our supervisor Roar Os Ådland for all the help, discussions, useful advices and for introducing us to valuable people. All the feedback and guidelines throughout the process are highly appreciated.

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1. Introduction

The offshore rig market is highly volatile and have experienced several ups and downs during the last decade. The most recent downturn came after the decline in the oil price from mid-2014. The effect of the drop in the oil price has been enhanced by an increased number of new rigs entering the market. A combination of these factors has resulted in decreased day rates and utilization rates, and overall challenging market conditions for the rig owners. The utilization rate is a percentage of the accumulated number of rigs in the market who are under contract, i.e. the number of rigs under contract divided by the total number of rigs available in the market. The day rate is the daily rate the rig owner receives from exploration and production companies (E&P) to explore and develop oil and gas fields.

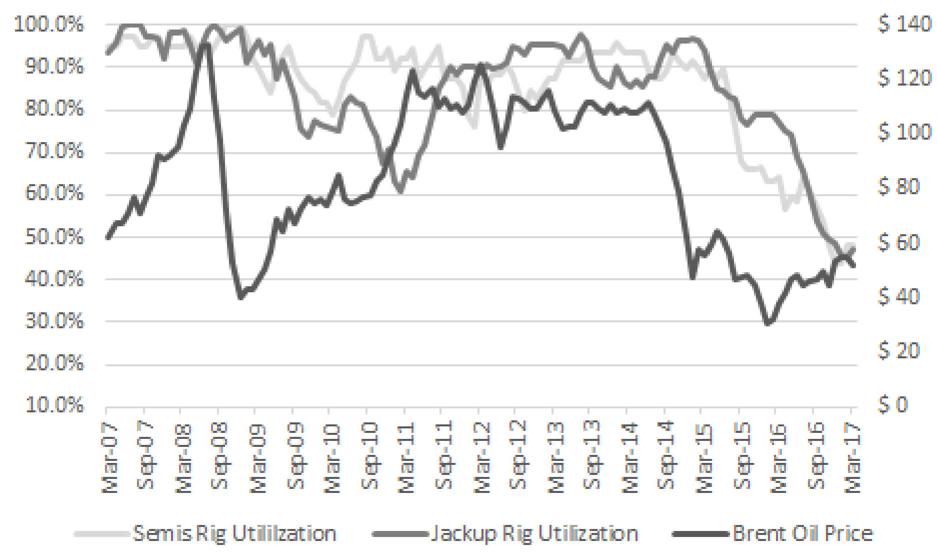

Figure 1 Utilization rate and crude oil price 2007-2017 (U.S. Energy Information Administration, RigLogix)

Figure 1 presents the development in the brent crude oil price and the utilization rate in the North Sea over the last ten-year period[1]. The plot shows how the utilization rate changes according to developments in the crude oil price. This is most visible in the periods following the financial crisis in the late 2000s, and after the drop in the crude oil price from mid-2014.

To cope with periods with poor market conditions, rig owners may use their opportunity to send rigs into lay-up. Laying up rigs involves a significant cost for the rig owner, both regarding sending a rig into lay-up, and reactivating it back into the market. A rig owner can choose

[1] We will use RigLogix' definition of the North Sea, which includes every rig located in the countries Denmark, Faroe Islands, France, Germany, Ireland, Netherlands, Norway and the UK (RigLogix, 2017b).

between two main types of lay-up; cold-stacking and ready-stacking. Ready-stacking a rig involves keeping important factors such as key personnel and maintaining the rig operational and ready to work if it receives a contract. Cold-stacking a rig is when the rig owner completely shuts down the rig and place it in a harbor, shipyard or a designated offshore are. Opposite of ready-stacking, cold-stacking significantly reduces the daily operational expenses of the rig. In such cases, most of the workers are let go and the crew is reduced to only a few key personnel.

The main motivation behind this thesis is to identify how rig characteristics and market conditions affect rig owners' decision to lay-up rigs in the period from 2010 to March 2017. The period is chosen because it contains two different market situations. The first period from 2010 to 2013 is characterized by good market conditions and optimism in the industry, while the opposite is the case for the second period from 2014-2017. By using a logistic regression model, we analyse if a given rig characteristic or market variable is a significant factor for the lay-up decision, and if the owners preferences have changed during the period from 2010 to 2017

Based on this, two research questions were formulated:

1. Which type of rig characteristics and specifications are important for the lay-up decision?
2. Is the market situation and future expectations important for the lay-up decision?

2. Literature review

The existing literature on the offshore rig market in the North Sea is limited. To our knowledge, no economical investigation regarding the lay-up decision have been carried out on the North Sea offshore rig market. Considering the economic significance of this industry, this is surprising. However, similar analyses have been done for offshore supply vessels (OSV) in the same area. Grøvdal & Tomren (2016) analyzed how day rates affects lay-up levels in the offshore supply industry in addition to other factors such as vessel characteristics. They used a logistic regression model to investigate how ship owners evaluate which ship to lay up and an OLS regression to study the relationship between day rates and the lay-up levels. However, they did not include any market variables in the logistic regression model, they exclusively considered vessel characteristics. Their findings were that day rates were negatively correlated with lay-up levels and that an increased vessel age would increase the possibility of a vessel being laid up. Larger clear deck area reduced the chance of lay-up for platform supply vessels (PSV), while bollard pull reduced the likelihood of lay-up for anchor handling tug supply vessels (AHTS). Tvedte & Sterud (2016) used a logistic regression model based on vessel characteristics to study the effect of obtaining a contract for OSV in the North Sea market. They found that some specifications, especially age, are important for a vessel to obtain a contract. However, similar to Grøvdal & Tomren (2016) a shortcoming to this analysis is that they have not included any variable to capture the effect the change in the market situation, i.e. the change in oil price, has on the OSVs ability to obtain contract. Alger & Banyte (2014) modelled the day rate using a multiple linear regression, and for idling behavior they presented the decision to cold-stack using a real option framework. They found that the accommodation capacity was the best predictive variable of cold-stacking for active rigs, where higher capacity makes a rig less likely to be cold-stacked. We want to build upon these analyses, include market variables and apply it to the rig market in the North Sea.

A paper that has inspired our work is Corts (2008). In his paper, he examined the role of firm and rig heterogeneity in drillers' decision about idling and reactivating capacity. He built a model based on decision rules and real option theory to decide when a rig will be laid up or reactivated back into the market. The conclusion was that a rig owner will only lay up a rig if the sum of the rig's profit and the option value to lay up a rig becomes less or equal to the present value of the reactivation costs. He used a binary model that includes variables for rig- and driller-specifications and market based time effects. Rig characteristics such as age, water depth and deck load were used as a proxy reflecting the rigs operating costs. A higher value of these characteristics is related to higher operating costs, making the rig more likely to be laid up. On the other hand, the same characteristics might lead to a greater upside if the market were to recover, and therefore have a greater option value. Characteristics that yields for higher potential revenue is therefore assumed to decrease the probability of a rig being laid up. To capture the importance of the size of the rig owner, he includes a variable that we have not seen in other existing literature concerning the offshore rig market. To see if the size of the company is significant in the lay-up decision, he introduced a variable that includes the total rigs a rig owner operates in the region. This builds further on Moel & Tuftano’s (2002) work on how the decision to shut down, or temporarily shut down a mine is related to firm-specific managerial factors not normally considered within a strict real option model. They discuss how large firms with several production units can lower their reactivation cost by relocating key personnel between different production facilities in periods with temporarily closing of mines, and thereby retain the human capital within the company. Inspired by Corts (2008) and this paper, we will analyze if firm size is a significant factor in the decision to send a rig into lay-up. In addition to Corts’ analysis of cold-stacked rigs, our analysis will consider ready-stacked rigs as well, to capture how the different variables varies among the two lay-up decisions.

Ringlund et al (2004) estimate relationships between oil rig activity and crude oil prices in non-OPEC regions using an Equilibrium Correction Model. They found a positive relationship between oilrig activity and the crude oil price, and how the strength of the relationship varies across regions. Osmundsen et al. (2012) discusses how contractual relationships affects rig rates for jackups in the Gulf of Mexico. They also include the effect of macroeconomic characteristics of gas and oil price in addition to the rig characteristics; age, technical depth, and a dummy for rig type. The analysis finds that current capacity in the rig industry is crucial to the bargaining power of the rig companies, and lead to high rig rates. The findings are the same for high expected future oil and gas prices. However, they state that oil and gas companies only partly respond to sudden shifts in the prices, they wait for some months to see if the change in the price level is permanent. Inspired by these reports, we will use macroeconomic variables in addition to rig characteristics, and add more rig characteristics than the three they used. In addition, our thesis will include analysis for both semi-submersible and jackup rigs.

3. Industry overview

Rigs are owned and operated by independent drilling contractors and leased to exploration and production (E&P) companies to explore and develop oil and gas fields (Osmundsen et al., 2012). Before a rig can operate in the North Sea, it needs to undergo classification and receive an Acknowledgement of Compliance by the governing unit of the drilling location (Petroleum Safety Authority Norway, 2017). Once a rig is classified, it must go through periodic surveys throughout its life period. The most comprehensive survey is the Special Periodic Survey (SPS), which is conducted on at least a five-year basis (Petrowiki, 2017). The rig contractors are paid a day rate by E&P companies for leasing a rig and its crew. The day rate differs between the different types of rigs. Generally, semi-submersibles are paid higher day rates than jackups due to their more advanced technology. The day rate is highly volatile and is driven by factors such as competition in the market, the rig utilization rate, the exploration activity of E&P companies and their expectations of future energy demand and oil and gas prices (Kaiser & Snyder, 2013). These companies are often engaged in several projects, where the expected profitability varies among the projects. The expected profit for each project increases if the expected future price for oil and gas increases. The E&P companies benefit from the use of rigs and are thereby dependent of the oil price, the gas price and the number of rigs hired (Osmundsen et al., 2012). The development of a field takes numerous years, and the lifetime of the field can be several decades. Due to this long-term investment horizon, E&P companies does not increase their activity based on short-run increases in the oil and gas price. However, the oil industry tends to increase drilling activity whenever the prices have stayed high for at least a six-month period (Abraham, 2000). Thus, rig activity can be used as an indicator for the field development taking place, and is an important signal for the future level of oil production (Ringlund et al., 2004).

The offshore rig market in the North Sea consist of three main types of drilling units; jackups, semi-submersibles and drillships. Each type is specified for drilling in different types of environment. Drillships will not be included in the thesis due to the fact that there are only three drillships currently located in the North Sea, and all of them are either cold- or ready-stacked. In addition, only one of these have drilled in the North Sea area recently. The thesis will therefore concentrate on the two main types; jackups and semi-submersibles.

A jackup is a mobile drilling rig supported by legs that rest on the seafloor, while semi-submersible is a rig with a platform-typed deck supported by pontoon-type columns (RigZone, 2017a). The semi-submersible is the most stable of any floating rigs, and is frequently used in harsh conditions due to their ability to withstand rough waters (RigZone, 2017b). This makes the transportation process relatively easy compared to the jackups. Some of the rigs are equipped with self-propulsion system, while others are towed to the drilling locations by tug boats or submersible barges. When the rig reach the drilling location, it uses mooring lines or its dynamic positioning (DP) system to keep the rig in place over the well. While jackups are suitable to drill in water up to 350 feet deep, semi-submersibles are able to operate as deep as 12,000 feet, and are therefore favorable in deep water operations.

Rigs can have various statuses depending on what type of operations they are hired to do, and there exists different interpretations of these. However, as this thesis collect data from RigLogix’ database, it will use RigLogix’ terminology as well (RigZone, 2017c). The main difference among the various statuses, and most important for our analysis, is whether the rig is under contract or if it is laid up.

A rig owner chose to lay-up a rig in times when the rig becomes unprofitable. The daily rate a rig manager receives from an E&P company can be extremely volatile and fluctuate during a year. In addition to a low day rate, the utilization rate can also be reduced by a significant amount during short time intervals. As a result, rig owners risk receiving a day rate that shifts from being higher than their operating expenses, to lower than their expenses in relatively short time intervals. To reduce its daily expenses, rig owners therefore have the possibility to lay-up unemployed or unprofitable rigs. Since the lay-up decision is most likely to be made when the costs exceed the profit, it is expected that a less efficient rig gets laid up before a homogeneous more efficient rig. Companies with the highest operating costs and lowest reactivation costs are most likely to lay up a rig first. Similarly, if a company has low reactivation costs, this makes it more likely to remove the rig from lay-up (Corts, 2008).

As mentioned in the introduction, a rig owner can choose among two main types of lay-up alternatives when laying up a rig; ready-stacking or cold-stacking. The economic and operational difference between these two are significant and should be carefully evaluated.

When a rig is ready-stacked, it is without a contract but is still operational. Ready-stacked rigs keep their key personnel, and are standing by ready to work if the rig operator receives a new contract. The operational expenses are slightly reduced below the level it has when the rig is actively working. Rig owners therefore choose to ready-stack a rig if it expects that the rig will return to a normal operation shortly (RigZone, 2017c). This can either be if it has a commitment from an E&P company on hand, or the rig management's own expectations for the future market developments.

When a rig is cold-stacked, it is completely shut down and stored in a harbor, shipyard or a designated offshore area. Opposite of ready-stacking, it significantly reduces the daily operational expenses down to the cost of insuring the rig and other costs such as harbor fees (Corts, 2008). The workers are let go and the crew is reduced to only a few key personnel. Before cold-stacking, some measures are taken to protect the rig, engines and equipment from corrosion. Rig owners chose to cold-stack a rig when they do not believe that they will find work that provides a daily rate above breakeven levels for an extended period of time (RigZone, 2017c). Such decisions are made in times when the market experience a downturn in demand for a given type of rig, or when marginal rigs need to undergo substantial investments to continue operations. If a rig is reactivated, significant reactivation costs are needed in terms of recruitment or training of a new crew. In addition, the equipment need to undergo substantial modifications and inspections by a governmental unit to get back into operational status. Cold-stacking of rigs has become more common during the last years due to the decrease in the industry activity. Since there are many young rigs in the market, experts are uncertain if the old rigs that are getting cold-stacked these days will be reactivated or eventually sold in the scarp market (RigZone, 2017d).

It is normal to separate the various rigs into the categories competitive and non-competitive rigs. Cold-stacked rigs and rigs that are state-owned or confined by geography are considered non-competitive (RigLogix, 2017b). The analysis will only include cold-stacked and competitive rigs.

4. Choice of variables

The chosen micro- and macroeconomic variables in this thesis are based on conversations with market analysts, the previous discussion, existing literature, and are specified in accordance with econometric principles[2]. Table 1 summarizes the independent variables with the expected sign of the coefficient for both rig types.

Maximum *water* and *drilling depth* is the maximum depth a rig can operate and drill in. A rig with deeper water and drilling depth is more flexible in regards of deep water operations, and a higher day rate may be rewarded. *Quarters capacity* is the number of workers a rig can accommodate, and v*ariable deck load* reflects the weight carried by the rig to support its operations. We expect that rigs with larger variable deck load do not need the same level of offshore supply support as smaller rigs, and thereby lowering the rigs operating costs. The *blowout preventer* (BOP) is used to seal, control and monitor oil and gas wells to prevent uncontrolled release of crude oil and/or natural gas from a well (Schlumberger, 2017). These rig characteristics all reflects the rigs capability to operate in the North Sea, and we expect that a higher value of these variables makes a rig less attractive to both cold- and ready-stack. The *age* of the rig is often important to an oil and gas operator, due to that older rigs often are related to higher operating costs, and a lower level of efficiency compared to younger rigs (Corts, 2008). We therefore expect that a higher age makes a rig more attractive to lay up.

While some rigs have their own propulsion method for transportation, others are moved assisted by tug boats or barges. When the rig is at the drilling location, it uses mooring lines or its *dynamic positioning* (DP) to keep the rig in place over the well. There are different types of DP. DP-1 is the simplest, while *DP-2* and *DP-3* are more advanced. It is expected that rigs equipped with *self-propulsion* and DP-systems are less attractive to both cold- and ready-stack. In the dataset, no jackups were equipped with self-propulsion or DP-system, and the variables are therefore only included for semi-submersibles.

Rigs operating in the North Sea often face harsh environment and a specification that may be more important in this specific area is *severe environment* classification. We expect this variable to increase in importance from the first to the second period, due to the increased exploration activity in the Barents Sea, and thereby lowering the probability of lay-up.

[2] To check for multicollinearity, correlation matrices (Appendix 2) and variance inflation factor tests (Appendix 3) are examined.

In addition to rig specifications, the analysis will also include a variable to capture the importance of firm size. The *number of rigs* in the market owned by a company may affect the decision to lay up a rig. When laying up a rig, the rig owners reduce both supply and the excess capacity in the market, and may thereby benefit from a higher day rate for the rigs that are still operating. By doing so, the operating rigs gets more profitable, and the companies with the largest fleet will gain more than companies with a lower number of rigs. Large firms also have the opportunity to relocate key personnel from laid up to operating rigs, and thereby reduce the risk of losing human capital (Moel & Tuftano, 2002; Corts, 2008). Keeping key personnel within the firm and not having to hire and train new crews makes the reactivation cost lower. Based on this, we expect to see that a higher value of the variable, *number of rigs,* makes a rig more attractive to both cold- and ready-stack.

To account for the underlying market conditions, the two macroeconomic variables; *day rate* and *oil futures price*, are included in the model[3]. The most representative version of the day rate would have been to include the day rate futures to capture the expectation of future rates. However, since it does not exist a futures markets for day rates, we decided to include the average monthly spot rate for jackups and semi-submersibles operating in the North Sea area. We tried to lag the day rate from 1-12 months, but the most significant result was the average spot price for the current month.

As mentioned, oil companies do not increase their exploration and production levels until they expect that the oil price will stay at a high level for some months. We therefore decided to include the four-month oil futures price instead of the spot price. The *expectation hypothesis* states that the futures price equals the expected value of the future spot price (Bodie et al., 2014). Even though it can be argued that this theory disregards the market risk, we found the futures price to be the best indicator for the future price levels. An alternative would have been to lag the oil spot price. However, this would have represented the experienced price level, and not the expected future level.

Since the two macroeconomic variables highly reflects the market situation, it is expected that the day rate and the oil futures will price have an important impact on the lay-up decision. Our prediction is that a higher value of these variables makes a rig less likely to be laid up.

[3] The four-month oil futures price is retrieved from EIA.gov (U.S. Energy Infromation Administration, 2017b)

As a result, two hypotheses are conducted, one for each type of rig.

1. Jackups with low age, deep water and drilling depth, high quarters capacity, high variable deck load, high blow out preventer pressure and severe environment classification are less likely to be cold- or ready-stacked. Lastly, large firm size is expected to increase the probability of lay-ups.
2. Semi-submersibles with low age, deep water and drilling depth, high quarters capacity, high variable deck load, high blow out preventer pressure, severe environment classification, equipped with self-propulsion and dynamic positioning system are less likely to be cold- or ready-stacked. Lastly, large firm size is expected to increase the probability of lay-ups.

Further, we expect that a higher value of the two market variables, day rate and oil futures price, will make the decision to both cold- and ready-stack a rig less desirable.

Table 1 Summary of variables and predictions

		Jackup			Semi-submersible		
			Prediction			Prediction	
Variable	Unit	Included	Ready-stack	Cold-stack	Included	Ready-stack	Cold-stack
Age	Years	x	+	+	x	+	+
Max WD	Ft	x	-	-	x	-	-
Max DD	Ft	x	-	-	x	-	-
Quarters Capacity		x	+/-	+/-	x	+/-	+/-
Variable Deck Load	Kips	x	+/-	+/-	x	+/-	+/-
Max BOP	Psi	x	+/-	+/-	x	+/-	+/-
Severe Env.		x	-	-	x	-	-
Firm Size		x	+	+	x	+	+
Day Rate	USD	x	-	-	x	-	-
Oil Futures Price	USD per Barrel	x	-	-	x	-	-
Self-Propelled					x	-	-
Dynamic Positioning or Moored					x		
DP-3						-	-
DP-2						-	-

5. Methodology and Data

5.1 Logistic regression

Logistic regression is a way to perform an analysis with binary outcome. This technique is therefore suited to analyze situations where the outcome is a "either-or" situation. The dependent variable can then take one of the two possible values; 0 or 1. In our analysis the outcome is defined as 1 if the rig is laid up and 0 otherwise.

$$y = \begin{cases} 1\ if\ the\ rig\ is\ stacked \\ 0\ if\ the\ rig\ is\ active \end{cases}$$

One problem with logistic regression is that it treats the dependent variable as continuous (Tufte, 2000). To overcome this issue, the regression model is formulated in such way that it is no longer limited to the interval 0 to 1. First, the upper limit is removed by transforming probabilities to odds. The odds express the relationship between the probability for occurrence (p) and the probability of non-occurrence (1-p).

$$Odds = \frac{p}{1-p} \tag{1}$$

The odds now have no upper limit, and can take a range from 0 to infinity. Second, the lower bound is removed by transforming odds to the log of odds. This is presented by the following formula:

$$L = \ln(\frac{p}{1-p}) \tag{2}$$

Log of odds, also called logit, is denoted by L, and can take the sample range from negative infinity to positive infinity. By transforming the probabilities to log odds, we have removed both the upper and lower bound for the dependent variable. In logistic regression, we use logit as the dependent variable because it is not restricted in a given interval, whereas the probability (p) move between 0 and 1.

The model can be formulated as:

$$L = ln\left(\frac{p}{1-p}\right) = b_0 + b_1x_1 + b_2x_2 + \cdots + b_kx_k + e \tag{3}$$

Where L is the logit (log of odds), $x_1, \ldots, x_2$ is the set of independent variables, e is the error-term, while b_0 is the constant and shows the average logit when all the independent variables in the model takes the value of 0. The other coefficients, $b_1, \ldots, b_k$, shows how much the logit or the log-odds change when an independent variable increase with one unit, and the other independent variables remain constant. All the coefficients are estimated using the maximum likelihood function, which calculates the coefficients that maximize the log of this function through several iterations. The iteration process starts with a model only including the constant, and all coefficients related to the independent variables equals zero. The last iteration maximizes log likelihood for the whole model.

The produced results from the logistic regression is not easily interpreted (Tufte, 2000). The coefficient for each of the independent variables will in our model show how much the logarithm of the odds for a rig to be laid up changes as the independent variables increase by one unit. A positive coefficient indicates that the log of odds for a rig to be laid up increase with a higher value of the independent variable, and thus increasing the probability of lay-up. The opposite interpretation is applied if a negative coefficient occurs.

In logistic regression, statistical significance of coefficients can be tested by calculating the asymptotic standard error (ASE). Whether a coefficient, β, is significant or not can be tested as a normal t-test or Z-test in an ordinary regression.

$$Z = \frac{\hat{\beta}}{ASE} \tag{4}$$

Coefficients in logistic regression are asymptotic normally distributed when the sample size approaches infinity, which implies that a large sample size is necessary for the Z-statistic to be reliable. Based on experience, Long (1997) states that the sample size should not be below 100, and preferably above 500. In our model, the sample size is not constant, but ranges from 184 to 475 observations.

Within ordinary regression analyzes, R^2 is the most common used measurement for goodness-of-fit (Wooldridge, 2016). R^2 measures how much of the variation in the dependent variable that can be explained by the predicted probability from the regression. However, if the purpose is to determine how much a specific variable affects the dependent variable directly or indirectly, the interpretation of R^2 is of little use. In logistic regression, McFadden's pseudo-R^2 is more commonly used. It builds upon the log likelihood function, and STATA produces a pseudo-R^2 when running the regression. Pseudo-R^2 range from 0 to 1, where a higher value implies that more of the variation in the dependent variable is explained by the model. A value of 0 implies that the model does not explain any of the variation in the dependent variable (Tufte, 2000). Unfortunately, there is no natural interpretation as in OLS, but the values can be used to compare how good different models for the same dependent variable in the same sample fits.

5.2 The logistic based model

The report aims to analyze the lay-up decision in the offshore rig market. First, cold-stacked and active rigs are analyzed. A rig is defined as active if it operates with a contract and/or obtain one of the following statuses; ready-stacked, drilling, workover, enroute, accommodation, modification or inspection. Only cold-stacked rigs will be defined as laid up. Second, all cold-stacked rigs are excluded from the market and ready-stacked rigs are compared with active rigs. Under these conditions an active rig is a rig which operates with a contract and obtains one of the following statuses; drilling, workover, enroute, accommodation, modification or inspection. Only ready-stacked rigs will be defined as laid up.

Four regression equations are then formulated, two for each type of rig. The first regression only includes rig characteristics, specifications and firm size, while the second also includes market variables[4]. The variables used in the econometric model are chosen based on conversations with market analysts and existing empirical studies. Based on this, the regressions for jackup (5 and 6) and semi-submersible (7 and 8) are formulated as following:

$$R_{i,t} = f\left(age_{i,t}mwd_{i,t}mdd_{i,t}qc_{i,t}vdl_{i,t}bop_{i,t}severe_{i,t}firmsize_{i,t}\right) \tag{5}$$

$$R_{i,t} = f\left(age_{i,t}mwd_{i,t}mdd_{i,t}qc_{i,t}vdl_{i,t}bop_{i,t}severe_{i,t}firmsize_{i,t}day\ rate_t oil\ futures\ price_t\right) \tag{6}$$

$$R_{i,t} = f(age_{i,t}mwd_{i,t}mdd_{i,t}qc_{i,t}vdl_{i,t}bop_{i,t}severe_{i,t}sp_{i,t}dp\ or\ moored_{i,t}dp\ rating_{i,t}firmsize_{i,t}) \tag{7}$$

$$R_{i,t} = f(age_{i,t}mwd_{i,t}mdd_{i,t}qc_{i,t}vdl_{i,t}bop_{i,t}severe_{i,t}sp_{i,t}dp\ or\ moored_{i,t}dp\ rating_{i,t}firmsize_{i,t} \tag{8}$$

$$day\ rate_t oil\ futures\ price_t)$$

The binary variable, $R_{i,t}$, will equal 1 if rig, *i*, is laid up at given time *t* and equal 0 if the rig is active. Further, the independent variable $age_{i,t}$, is the age of rig *i* in period *t*, $mxd_{i,t}$, is the maximum water depth the rig can operate in, $mdd_{i,t}$, is the maximum drilling depth, $qc_{i,t}$, defines the maximum number of workers accommodated on the rig, $vdl_{i,t}$, is the weight of items carried by the rig to support its operation that are not included in the fix load, $bop_{i,t}$, indicates the maximum blowout preventer pressure and $firmsize_{i,t}$, is the number of jackups or semi-submersibles a given rig manager operates in the North Sea market in period *t*.

[4] Individual regressions are also run separately for the market variables. The result can be seen in Appendix 1.

Further, $severe_{i,t}, sp_{i,t}, dp\ or\ moored_{i,t}\ and\ dp\ rating_{i,t}$ are dummy variables indicating whether a rig i is capable of working under severe environment, is self-propelled, uses dynamic positioning or mooring lines and which type of dynamic positioning system the rig has installed. Lastly, $day\ rate_t$ and $oil\ futures\ price_t$ represents the day rate for the given rig type and oil futures price corresponding with period t.

5.3 Description of dataset

The rig data in this thesis are retrieved from Rig Logix' database (RigLogix, 2017a). The source provides data for all rigs operating in the North Sea market, with detailed specifications for each rig. Based on this data, new datasets including age, rig characteristics and specifications are developed. The datasets exclude rigs that have not operated on contract in the North Sea within the given period. This ignores rigs that operates in other markets, but for various reasons are laid up, undergoing modifications or inspections in the North Sea market. Some rigs are only in the North Sea for a limited period. As long as the rig is drilling, these observations are included while on contract, but excluded when it is removed from the market.

Since the North Sea market is dominated by semi-submersibles and jackups – all other rigs are excluded from the model. To give a more precise analysis, cold-stacked rigs are left out when analyzing the decision to ready-stack a rig. This decision is based on the assumption that cold-stacked rigs are non-competitive and not likely to be ready-stacked after the cold-stacking decision is made. When analyzing the cold-stacking decision, ready-stacked rigs are included because they still compete for a contract, and the decision to cold-stack the rig is still available.

The statistics for semi-submersibles are shown in table 2. As we can see, there is a significant increase in the number of rigs in every year throughout the period, except for 2017. As for the first years, the utilization rates were mostly above 80%, which indicates a higher probability for investments, and in this case newbuildings. Further, the utilization rate decreases from mid-2015, and newbuildings are less likely to enter the market. As 2017 gets underway, contractors have already deferred delivery of some rings into 2018 or beyond (RigZone, 2017d). This due to the fact that the market is flooded with young rigs that are just as capable as a newbuilding. These young rigs already have work history and save an operator from the typical break-in period required for a new rig. The average age and firm size is more or less constant throughout the period, increasing from 23 to 25 years, and 6 to 7 rigs. Further, a clear trend towards deeper water depth and drilling depth, as well as larger quarters capacity, variable deck load and blow out preventer pressure is shown. In addition, the statistics indicates a clear trend towards more complex rigs.

The average day rate for semi-submersibles varied from 2010 and throughout 2015, before decreasing in 2016 and 2017. The development of the oil futures price is observed with a relatively rapid increase from 2010 and throughout 2014, before decreasing by 44% in 2015. The percentage of rigs classified for severe environment increased from 47% to 67%, and the number of self-propelled semi-submersibles increased from 58% to 61%. Further, rigs with dual positioning system installed increased with 93% from 2010 to the end of the period, where 95% of rigs in 2017 with dual positioning system got DP-3, compared to 88% in 2010.

Table 3 shows the descriptive statistics for jackups. The number of jackups in the North Sea market increased with 39% from 38 to 53 rigs throughout the period. The utilization rate remained high from mid-2011 and throughout 2014, before decreasing from January 2015. This is in line with the development of the oil price, increased number of rigs in 2014 and the decrease in average age due to newbuildings entering the market.

The statistic overview indicates a trend towards larger rigs with deeper water depth and drilling depth. As well as larger quarters capacity, variable deck load and blow out preventer pressure. Average firm size remains more or less constant throughout the period, while jackups that are classified for severe environment increased with 13% in the time-period. The trend towards more complex jackups may be the reason for the increased day rate throughout the period. However, a drop in the day rates is observed in 2016, which reflects the challenging market situation at that time.

In short, a clear trend towards larger and more complex rigs are observed. For both semi-submersibles and jackups, we see a clear trend towards deeper drilling and water depth, larger values for quarters capacity, variable deck load and blow out preventer pressure. Further, we see a higher proportion of rigs classified for severe environment, as well as an increased number of semi-submersibles equipped with self-propulsion and dual positioning system. The development in the average day rates differs between the two rig types. The day rate for jackups increased with 30% from 2010 to 2017, while it decreased by 14% for semi-submersibles. Lastly, the oil futures price decreased by 35% when the levels from 2010 is compared with 2017.

Table 2 Descriptive statistics for semi-submersible 2010-2017

	2010	2011	2012	2013	2014	2015	2016	2017	Change 2010-2017
No. of rigs	36	39	42	47	50	50	53	49	36.11 %
Avg. Age	24	24	24	23	25	25	24	24	0.00 %
Avg. WD	2846	2772	2907	3410	3247	3250	3471	3631	27.58 %
Avg DD	26002	25815	25995	26401	26217	26426	26838	26988	3.79 %
Avg. QC	107	107	108	112	111	113	117	118	10.28 %
Avg. VDL	8706	8712	8801	9292	9051	9164	9549	9735	11.82 %
Avg. BOP	13889	13974	14048	14149	14100	14000	13868	13980	0.66 %
Avg. Firm Size	8	8	8	7	8	7	7	6	-25.00 %
Avg. Day Rate	397511	380577	367318	386689	392934	392609	367305	343604	-13.56 %
Avg. Oil Futures Price	82	97	95	97	91	51	46	53	-35.37 %
% Severe Env.	47 %	51 %	52 %	60 %	58 %	60 %	64 %	67 %	42.62 %
% Self-propelled	58 %	59 %	57 %	60 %	54 %	54 %	58 %	61 %	4.96 %
% DP	22 %	21 %	21 %	34 %	30 %	34 %	40 %	43 %	92.86 %
% DP-2	13 %	13 %	11 %	6 %	7 %	6 %	5 %	5 %	-61.90 %
% DP-3	88 %	88 %	89 %	94 %	93 %	94 %	95 %	95 %	8.84 %

Table 3 Descriptive statistics for jackups 2010-2017

	2010	2011	2012	2013	2014	2015	2016	2017	Change 2010-2017
No. Of Rigs	38	42	39	41	49	52	52	53	39.47 %
Avg. Age	19	18	19	19	18	17	17	18	-5.05 %
Avg. WD	342	339	345	347	359	365	366	369	7.89 %
Avg. DD	27895	28127	28624	28813	30333	30795	30737	30912	10.82 %
Avg. QC	106	106	106	106	113	115	116	116	10.29 %
Avg. VDL	10001	9763	10229	10152	11115	11849	11721	12039	20.39 %
Avg. BOP	13289	13333	13333	13415	13673	13750	13173	13208	-0.62 %
Avg. Firm Size	7	7	6	6	8	8	8	8	21.12 %
Avg. Severe Env.	68 %	69 %	69.23 %	70.73 %	75.51 %	76.92 %	76.92 %	77.36 %	13.06 %
Avg. Day Rate	158136	148952	168527	188961	209859	227400	207563	205967	30.25 %
Avg. Oil Futures Price	82	97	95	97	91	51	46	53	-35.37 %

6. Empirical results and discussion

The data is retrieved from the dataset, and three panel logit models are estimated, one for each of the time intervals; 2010-2013, 2014-2017 and 2010-2017. This is done for both jackups and semi-submersibles. The results are shown in tables 4 and 5 for jackups, and tables 6 and 7 for semi-submersibles. As previously mentioned, the first period from 2010 to 2013 where characterized by high utilization rates and a low number of rigs being laid up. It is therefore important to interpret the regression results with caution due to the low number of observed lay-ups, that may cause unreliable results.

6.1 Jackup

The results from equation 5 and 6 for jackups are reported in table 4 and 5, indicating that older rigs are more likely to be laid up. However, the degree of importance and lay-up alternative varies throughout the periods. In the first period with good market conditions and a low number of rigs being laid up, older rigs were more likely to be ready-stacked. This seemed to change towards the cold-stacking decision when the market conditions became worse. As the market turned, the importance of rig *age* also became more significant and a higher number of rigs were sent into lay-up. In addition to the challenging market conditions, the older rigs experienced increased competition from the newbuildings who entered the market during the previous period. These rigs had their break-in-period before the market situation turned, and thus became more attractive for an operator and made it harder for older rigs to gain new contracts (RigZone, 2017d). Looking at the whole seven-year period, the results shows that age is more important for the decision to cold-stack rather than to ready-stack.

The standard characteristics, *max water depth*, *variable deck load*, *quarters capacity* and *BOP max* were all expected to decrease the probability of lay-up. However, this is not observed in the regression results, except for max water depth which reduces the likelihood of ready-stacking in the first period, and for the whole seven-year period. When the first period is considered, variable deck load was the only of the rig characteristic variables contradicting our hypothesis, and increased the probability of ready-stacking, though at a low level of significance. In the period from 2010 to 2017, variable deck load, quarters capacity and BOP max are all observed with positive coefficients for the decision to cold-stack a rig, while only quarters capacity were significant for the ready-stacking decision. Even if this results does not comply with the expectations, it can be explained through Corts (2008) reasoning that a higher value of these rig characteristics leads to higher operating costs, and thereby increasing the probability of lay-up. In a period with varying market conditions, a higher value of such characteristics may be looked upon as redundant, and the benefit of lower operating costs might exceed the advantage of possibly achieving a higher profit.

The variable *severe environment* is observed with a weak significant coefficient of positive magnitude in the 2010-2013 period, and thereby increasing the likelihood of ready-stacking. Jackups operates in shallow waters in the southern part of the North Sea, and the classification for severe environment may therefore be looked upon as redundant for this type of rig.

For the variable *number of rigs,* highly significant results were observed for the cold-stacking decision in the most recent period, and for the period as a whole. The coefficients were of negative magnitude, indicating that a higher value makes a jackup less likely to be cold-stacked. The results contradict the hypothesis and the existing literature. Moel & Tuftano (2002) and Corts (2008) finds that companies with more units in the market are more likely to lay up units due to lower reactivation costs and the opportunity to relocate key personnel, and thus maintain them within the company. However, our result may indicate that large companies with multiple units uses the ability to cross-subsidize poor performing rigs with profit from more efficient rigs, and thereby keep them in the market. According to market analysts, an advantage of keeping rigs in the market is that active rigs are more favorable than laid up rigs for oil companies. Keeping the rig in the market may therefore increase the probability of a rig receiving a new contract.

Table 4 Jackups - Rig characteristics, specifications and firm size

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.134	0.0750*	0.130**	0.00172	0.202****	0.0342*
	(0.212)	(0.051)	(0.024)	(0.933)	(0.001)	(0.056)
Max Water Depth	0.00193	-0.0341***	-0.0032	0.000048	-0.0146	-0.00768*
	(0.841)	(0.007)	(0.791)	(0.993)	(0.132)	(0.088)
Max Drilling Depth	-0.0000629	0.0000356	0.0000377	-0.0000404	0.0000577	-0.00000748
	(0.686)	(0.722)	(0.749)	(0.492)	(0.545)	(0.878)
Quarters Capacity	0.0454	0.0334	-0.0000214	0.00743	0.0492**	0.0245*
	(0.266)	(0.186)	(0.999)	(0.625)	(0.026)	(0.051)
Variable Deck Load	0.000228	0.000240*	0.000111	-0.000104	0.000200**	-0.0000481
	(0.109)	(0.087)	(0.349)	(0.108)	(0.044)	(0.383)
BOP Max		0.0000969	0.000142	-0.0000251	0.000584***	0.0000602
		(0.633)	(0.489)	(0.848)	(0.005)	(0.550)
Number Of Rigs	-0.168	-0.0149	-0.426****	-0.00178	-0.300****	0.0244
	(0.324)	(0.886)	(0.000)	(0.970)	(0.000)	(0.554)
Severe Environment	-0.808	2.567*	0.238	0.213	-0.19	0.435
	(0.568)	(0.051)	(0.777)	(0.686)	(0.757)	(0.314)
Constant	-10.67	-2.192	-6.164	0.438	-17.36***	-2.746
	(0.253)	(0.630)	(0.275)	(0.852)	(0.002)	(0.174)
Observations	206	197	269	251	475	448
McFadden pseudo-R^2	0.1918	0.1557	0.2974	0.0446	0.2682	0.0444

p-values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

In the second part of the analysis for jackups, we included the market variables *oil futures price* and *day rate*. As these two variables affect of each other, we expected them to be highly correlated. The correlation matrices showed a correlation of approximately 80%. In theory, this could be a problem regarding multicollinearity. However, after investigating the variance inflation factor test, we concluded that both variables could be used in the same model[5]. Some of the variables in the analysis without the market variables are still significant, while some loss their degree of significance. The variable *age* is now significant in the 2010-2013 period for the cold-stacking decision, while *number of rigs* is significant for the ready-stacking in the 2014-2017 period, however, both at a weak level. The interpretation of the existing variables will be as before.

The value of the McFadden-R^2 tends to increase for both the cold- and ready-stacking situations when the two market variables are included. Generally, it is at a high level for the cold-stacking decision in all the three periods. However, for the ready-stacking decision it is at a relatively low level in the 2014-2017 and 2010-2017 period. This may indicate that the model is better suited to explain the decision to cold-stack than to ready-stack a rig, and struggles capture the effect of the variables in periods with challenging market conditions.

[5] For correlation matrices and variance inflation factor test see Appendix 2 and 3.

The day rate was significant for both lay-up decisions in the first and the seven-year period. The magnitude of the coefficient was negative, indicating that an increasing day rate will make lay-up less attractive. This is in accordance with the predictions and existing literature. A higher day rate results in higher profits and makes more rigs economically efficient.

Oil futures price is significant in all periods for both cold- and ready-stacked jackups. As for the day rate, the coefficient is of negative magnitude indicating that an increase in the oil futures price will reduce the probability of laying up jackups. For the decision to ready-stack, the level of significance is strong for each period. However, the level of significance in regards of the cold-stacking decision varies from weak in the first period to strong for the whole period. The expected profit of a drilling operation is dependent of the oil price, and a higher expectation for future oil price directly increase the expected profit. Osmundsen et al. (2012) finds evidence that higher oil price leads to higher rig utilization rate and higher day rates for jackups in the Gulf of Mexico. Based on our results, one can assume that this applies for the North Sea market as well.

Table 5 Jackups - Rig characteristics, specifications, firm size and market variables

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.257^{*}	0.115^{*}	0.123^{**}	0.000751	0.179^{***}	0.0304^{*}
	(0.079)	(0.073)	(0.015)	(0.972)	(0.003)	(0.096)
Max Water Depth	0.0185	-0.0318^{**}	-0.00248	0.000126	-0.0148	-0.00762
	(0.147)	(0.034)	(0.843)	(0.981)	(0.141)	(0.109)
Max Drilling Depth	0.0000311	0.0000564	0.0000267	-0.00003	0.0000254	-0.000011
	(0.852)	(0.606)	(0.819)	(0.622)	(0.803)	(0.830)
Quarters Capacity	0.0212	0.0235	-0.00882	0.00242	0.0368	0.0136
	(0.592)	(0.450)	(0.738)	(0.877)	(0.110)	(0.297)
Variable Deck Load	0.000267	0.000253	0.000107	-0.000108	0.000208^{**}	-0.0000434
	(0.123)	(0.127)	(0.382)	(0.104)	(0.046)	(0.451)
BOP Max		0.000199	0.0000993	-0.000058	0.000554^{**}	0.0000361
		(0.402)	(0.641)	(0.676)	(0.010)	(0.739)
Day Rate	-0.000111^{**}	-0.0000877^{***}	-0.458^{****}	-0.0242	-0.0000331^{**}	-0.0000275^{***}
	(0.043)	(0.005)	(0.000)	(0.618)	(0.038)	(0.001)
Oil Futures Price (4-months)	-0.103^{*}	-0.122^{****}	-0.000034	-0.0000311	-0.0565^{***}	-0.0582^{****}
	(0.068)	(0.000)	(0.342)	(0.114)	(0.002)	(0.000)
Numb Of Rigs	-0.326	-0.0965	-0.0473^{**}	-0.0413^{****}	-0.346^{****}	-0.0371
	(0.103)	(0.444)	(0.025)	(0.000)	(0.000)	(0.390)
Severe Environment	-1.13	2.805^{*}	0.548	0.425	0.0169	0.727
	(0.458)	(0.073)	(0.542)	(0.448)	(0.980)	(0.118)
Constant	8.67	20.58^{**}	5.365	10.11^{*}	-3.805	8.412^{***}
	(0.521)	(0.021)	(0.591)	(0.051)	(0.580)	(0.005)
Observations	206	197	269	251	475	448
McFadden pseudo-R^2	0.3048	0.3163	0.3428	0.1090	0.3247	0.1441

p -values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

6.2 Semi-submersible

In the period from 2010 to 2013, some variables had to be excluded. None of the cold- or ready-stacked semi-submersibles were equipped with *DP-2* or *DP-3*, and a maximization of the log likelihood was not possible. The same applies for the variable *severe environment* regarding the cold-stacking decision. Lastly, *variable deck load* and *quarters capacity* are excluded for the cold-stacking situation due to a large number of empty cells, and thereby failures in the maximization process. In contrast to the situation for jackups, none of the variables were significant in the first period, and will therefore not be further discussed.

The results from equation 7 and 8 are reported in table 6 and 7. As for jackups, the *age* of a semi-submersible is an important factor for the lay-up decision in the North Sea offshore rig market. In the period from 2014 to 2017, the market experienced decreasing day rates and a higher number of laid up rigs compared to the previous period. In this period, the rig age was highly significant for the decision to cold-stack a semi-submersible, and when the seven-year period was considered, age was highly important for both lay-up alternatives. The results indicate that a higher age increases the probability of a semi-submersible being laid up.

In the 2014-2017 period, *quarters capacity* is observed with a negative coefficient for the cold-stacking decision, indicating that increased quarters capacity leads to lower probability of cold-stacking. However, when the whole period is taken into account, we see that the result differs between the two lay-up alternatives. A higher value of the variable still decreases the probability for cold-stacking, but the opposite result is observed for the decision to ready-stack a semi-submersible. Higher quarters capacity means that the rig can accommodate a larger number of workers. This may result in higher operating costs due to a larger crew, but at the same time higher potential revenues. This could indicate that a rig owner would rather ready-stack than cold-stack a rig. The rig owner would thereby keep the human capital within the company, and not risk substantial reactivation cost in regard to recruiting and training of new personnel if the rig gets reactivated.

No other variables were statistically significant in the two periods 2010-2013 and 2014-2017. However, for the period as a whole, several variables are observed with statistically significant values. *Max water depth* is noted with a negative coefficient for the cold-stacking decision. Generally, semi-submersibles operate at deep water levels, and throughout the period, the average water depth semi-submersibles operated in increased with approximately 20%[6]. A higher value of max water depth may therefore be favorable for semi-submersibles. This is in accordance with the predictions related to the variable. However, the corresponding level of significance is low, and the drawn conclusion have to be carefully evaluated.

The last significant rig characteristic variable is *variable deck load*. According to our predictions, a negative coefficient was expected. However, the result is noted with a positive magnitude, and thereby increases the probability for cold-stacking in the 2010-2017 period. The unexpected result can, as for jackups, be explained through the theory of Corts (2008). A rigs characteristics reflects the operating costs, and in a period with varying market conditions, lower operating costs might be more favorable than a larger variable deck load.

Further, the three specifications *self-propelled*, *severe environment* and *DP-systems* are considered. Self-propelled rigs do not need the same assistance in regards of transportation. This does not only affect the costs, but also the availability of the rig in regards of preparation and scheduling for drilling operations. Semi-submersibles often face harsh conditions, and self-propelled and severe-environment are therefore considered as important specifications. The two variables are both significant for the cold-stacking decision in the 2010-2017 period. In accordance with our predictions, the coefficient is negative, indicating that semi-submersibles with such specifications are less likely to be cold-stacked. As for self-propelled and severe environment, we expected that rigs with DP-systems installed would be less likely to be laid up, but the results show otherwise. *DP-3* is noted with a positive coefficient for both of the lay-up decisions in the 2010-2017 period, and thereby increasing the probability of cold-stacking. After investigating the result and data behind, the reasoning of the result can be explained through low numbers of observations for both cold- and ready-stacked rigs with a DP-3 system installed. This could have produced a large proportion of empty cells, and spurious results may occur. Only 23% of the semi-submersibles being lay-up in the 2010-2017 period had DP-3 system installed, while 74% of the semi-submersibles sent into lay-up were moored. Based on this, we conclude that DP-3 makes a semi-submersible less likely to be laid up, even though the regression results show otherwise.

[6] Average water depth is calculated from Norwegian Petroleum Directorate's database for exploration activity (Norwegian Petroleum Directorate, 2017).

Table 6 Semi-submersibles - Rig characteristics, specifications and firm size

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.153	0.00202	0.166***	0.028	0.263****	0.0753**
	(0.236)	(0.978)	(0.006)	(0.424)	(0.000)	(0.011)
Max Water Depth	-0.000218	-0.00168	-0.000255	-0.0000652	-0.000561*	-0.000147
	(0.859)	(0.334)	(0.366)	(0.595)	(0.056)	(0.211)
Max Drilling Depth	0.000131	-0.000176	0.000177	0.0000199	0.000165	-0.0000254
	(0.915)	(0.312)	(0.159)	(0.818)	(0.185)	(0.726)
Quarters Capacity		0.0318	-0.0643*	0.0122	-0.0644**	0.0271**
		(0.493)	(0.052)	(0.381)	(0.05)	(0.025)
Variable Deck Load		0.000272	0.000287	-0.0000126	0.000797***	0.0000674
		(0.535)	(0.281)	(0.940)	(0.004)	(0.665)
Number Of Rigs	0.523	0.00539	-0.0339	-0.0145	0.0214	0.00755
	(0.215)	(0.940)	(0.574)	(0.726)	(0.652)	(0.813)
BOP Max	-0.000156	-0.000071	-0.0000652	0.0000873	-0.000052	0.0000773
	(0.443)	(0.652)	(0.523)	(0.368)	(0.550)	(0.319)
Self-Propelled	-0.13	-0.619	-0.464	0.122	-0.726*	-0.0388
	(0.888)	(0.445)	(0.315)	(0.742)	(0.090)	(0.904)
DP-2			0.496	0.75	-0.369	0.353
			(0.743)	(0.517)	(0.797)	(0.733)
DP-3			2.641	0.903	4.443***	1.891**
			(0.091)	(0.369)	(0.003)	(0.024)
Severe Environment		-0.722	-0.851	-0.532	-1.001*	-0.244
		(0.485)	(0.146)	(0.281)	(0.086)	(0.551)
Constant	-15.62	0.471	-5.006	-4.471	-12.32**	-7.458***
	(0.582)	(0.960)	(0.408)	(0.150)	(0.024)	(0.005)
Observations	191	184	271	233	462	417
McFadden pseudo-R^2	0.3477	0.1297	0.2000	0.0169	0.2302	0.0322

p -values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

Lastly, the market variables *day rate* and *oil futures price* were included in the regression for the semi-submersibles. As for jackups, some of the variables lost their degree of significance, while others remained the same or gained significance. The variables *age* and *quarters capacity* lost their significance for the ready-stacking situation, while *severe environment* is now significant for both lay-up decisions in the 2010-2017 period. Still, none of the variables were significant in the first period. This can be explained through the good market conditions at that time, and thereby making semi-submersibles less attractive to lay up.

We observe that the value of the McFadden pseudo-R^2 increases when the market variables are included in the model, especial for the ready-stacking decision in the 2014-2017 and 2010-2017 period. As for jackups, we see that the model is better suited to explain cold- than ready-stacking. Unlike the situation for jackups, the McFadden pseudo-R^2 increases throughout the periods for the ready-stacking decision. Since some variables had to be excluded due to failures in the 2010-2013 period, this may indicate that these variables increase the explanatory power of the model.

From the results, we observe that day rate is highly significant and of negative magnitude for both cold- and ready-stacking in the last period, and when the whole period is considered.

According to our predictions, the result confirms that the day rate is an important factor and affects the decision to send a semi-submersible in the North Sea market into lay-up. Finally, the results for the oil futures price are considered. In the first period, the oil futures price is highly significant for the ready-stacking decision, and noted with a negative coefficient. Further, the whole period is investigated, and again the oil futures price is shown with a highly significant and negative coefficient, both regarding cold- and ready-stacking. This result confirms the existing literature and our prediction; a higher value of the expected future oil price decrease the likelihood for a semi-submersible being laid up.

Table 7 Semi-submersibles - Rig characteristics, specifications, firm size and market variables

	2010-2013		2014-2017		2010-2017	
	Cold Stacked	Ready Stacked	Cold Stacked	Ready Stacked	Cold-Stacked	Ready-Stacked
Age	0.14	0.0204	0.130**	-0.00199	0.186***	0.00494
	(0.296)	(0.801)	(0.034)	(0.958)	(0.001)	(0.878)
Max Water Depth	-0.000316	-0.00146	-0.000139	0.00000296	-0.000377	0.0000199
	(0.81)	(0.391)	(0.619)	(0.982)	(0.185)	(0.865)
Max Drilling Depth	0.000191	-0.000163	0.000220*	0.0000846	0.000191	0.00000534
	(0.868)	(0.356)	(0.087)	(0.391)	(0.140)	(0.948)
Quarters Capacity		0.0374	-0.0771**	-0.000151	-0.0808**	0.0056
		(0.427)	(0.023)	(0.992)	(0.013)	(0.681)
Variable Deck Load		0.000274	0.000123	-0.000141	0.000540*	-0.0000599
		(0.529)	(0.652)	(0.444)	(0.055)	(0.715)
Numb Of Rigs	0.477	0.012	-0.0189	0.00526	0.0408	-0.00923
	(0.191)	(0.868)	(0.772)	(0.915)	(0.437)	(0.806)
BOP Max	-0.000156	-0.00005	-0.000104	0.000106	-0.000124	0.0000232
	(0.450)	(0.754)	(0.325)	(0.311)	(0.176)	(0.784)
Day Rate	-0.00000167	0.0000148	-0.0000311***	-0.0000426****	-0.0000322***	-0.0000358****
	(0.979)	(0.690)	(0.008)	(0.000)	(0.006)	(0.000)
Oil Futures Price (4-months)	0.0245	-0.023	-0.0146	-0.0459****	-0.0232***	-0.0397****
	(0.715)	(0.559)	(0.212)	(0.000)	(0.006)	(0.000)
Self-Propelled	-0.116	-0.641	-0.501	0.0386	-0.708	-0.00115
	(0.901)	(0.431)	(0.294)	(0.925)	(0.110)	(0.997)
DP-2			0.842	1.533	0.0261	0.661
			(0.593)	(0.240)	(0.986)	(0.559)
DP-3			2.083	0.306	3.383**	0.165
			(0.196)	(0.781)	(0.026)	(0.861)
Severe Environment		-0.556	-0.862	-0.855	-1.167*	-0.863*
		(0.597)	(0.151)	(0.119)	(0.056)	(0.063)
Constant	-17.57	-5.303	10.49	15.40***	7.575	14.39***
	(0.640)	(0.792)	(0.190)	(0.003)	(0.328)	(0.002)
Observations	191	184	271	233	462	417
McFadden pseudo-R^2	0.3509	0.1382	0.2446	0.1661	0.2905	0.1870

p -values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

7. Conclusion

The purpose of the thesis was to investigate the lay-up decision in the North Sea offshore rig market in the period from January 2010 to March 2017. We have analyzed the characteristics and specifications rig analysts consider most important, and how they affect rig owners' decision to lay up a rig. In addition, we included variables to capture both the importance of firm size and market conditions.

The results for jackups varies between the two lay-up decisions, cold- and ready-stack. In the first and the seven-year period, younger rigs with deep *water depth* were less likely to be ready-stacked. Further, young rigs owned by companies with multiple rigs in the North Sea were less likely to be cold-stacked in the second period, as well as for the whole period. The rig characteristics *variable deck load*, *quarters capacity* and *BOP max* all increased the probability of cold-stack in the seven-year period, while *severe environment* increased the likelihood of ready-stack in the first period.

There were no significant results produced for semi-submersibles during the first period. This is most likely due to good market conditions, and thereby a low number of semi-submersibles being laid up. After the market turned in 2014, *age* and *quarters capacity* seemed to be important for rig owners' decision to cold-stack a semi-submersible, and they would rather keep young rigs with a high quarters capacity in the market. For the whole period, a semi-submersible's age affected the level of both cold- and ready-stacking. However, the effect seemed to be stronger for cold-stacking than for ready-stacking. Regarding the rig characteristics and specifications, *max water depth*, *quarters capacity*, *self-propulsion*, *DP-3* and *severe environment* were valued features that decreased the likelihood of cold-stacking, while a higher value of *variable deck load* increases the probability. A notable result is *quarters capacity*. An increase in this feature decreased the probability of cold-stack, but made the semi-submersible more likely be ready-stacked.

The regression results show that a higher day rate and expectations for the future oil price strongly decrease the likelihood for both jackups and semi-submersibles being laid up.

We do acknowledge that there exist some limitations to this thesis. First, rigs often operate on long-term contracts. Therefore, there may be a delay in adjusting to changes in the day rate that we have not captured in our model. Second, the value of the McFadden pseudo-R^2 is generally at a low level for the ready-stacking decision, which may indicate that the model struggles to explain this decision. Third, we were not able to implement a variable for special periodic survey (SPS). This is an important factor that oil companies consider when they are hiring rigs, especially for long-term contracts. After contacting companies responsible for performing surveys and the Petroleum Safety Authority Norway, we learned that there does not exists any list of which rigs that are due to classifications or surveys at a given date. We therefore found it difficult to include this feature to our analysis. A variable for SPS could have been implemented by creating a proxy related to the age of the rig. However, when laid up, rigs do not go through an SPS before they are reactivated back into the market. Thus, such proxy could cause a misleading result, and thereby not capture the effect we initially wanted. Other variables that could have made the results more solid, would have been to implement variables to capture a rigs experience in the North Sea and its prior operating state. There are other factors affecting the lay-up decision than we have included in our model. It would have been interesting to see how a company's financial situation affect the decision to lay up a rig. Especially in times where there are challenging market conditions. These suggestions build a foundation for further research of the offshore rig market in the North Sea, and we hope other students will address these highly interesting topics.

References

Abraham, K. S. (2000). A Revised Global Drilling Outlook for 2000 and Update on Iraq. *Journal of Energy and Development*, pp. 203-2015.

Alger, H., & Banyte, J. (2014). *From Sea to Shining Sea? An econometric inquiry into the offshore mobile rig market.* Bergen: Norwegian School of Economics.

Bodie, Z., Kane, A., & Marcus, A. J. (2014). *Investments.* Berkshire: McGraw-Hill Education.

Corts, K. S. (2008). *Stacking the Deck: Idling and Reactivation of Capacity in Offshore Drilling.* Toronto: Rotman School of Management.

Grøvdal, L. V., & Tomren, M. (2016). *The Lay-Up Decision in Practice.* Bergen: Norwegian School of Economics.

Kaiser, K., & Snyder, B. (2013). *The Offshore Drilling Industry and Rig Construction in the Gulf of Mexico.*

Long, S. J. (1997). *Regression Models for Categorical and Limited Dependent Variables.* SAGE Publications Inc.

Moel, A., & Tuftano, P. (2002). *When Are Real Options Exercised? An Empirical Study of Mine Closings.* Oxford University Press. Retrieved from http://www.jstor.org/stable/2696798

Norwegian Petroleum Directorate. (2017). *Factpages - Wellbore*. Retrieved June 11, 2017, from Norwegian Petroleum Directorate: http://factpages.npd.no/factpages/Default.aspx?culture=nb-no&nav1=wellbore&nav2=Statistics%7CEntryYear

Osmundsen, P., Rosendahl, K. E., & Skjerpen, T. (2012). *Understanding Rig Rates.* Statistics Norway.

Petroleum Safety Authority Norway. (2017). *What is an acknowledgement of compliance?* Retrieved May 15, 2017, from Petroleum Safety Authority Norway: http://www.ptil.no/what-is-an-acknowledgement-of-compliance/category952.html

Petrowiki. (2017). *Classification and registration of offshore drilling units*. Retrieved May 14, 2017, from Petrowiki: http://petrowiki.org/Classification_and_registration_of_offshore_drilling_units

RigLogix. (2017a). Retrieved April 25, 2017, from RigLogix: http://www.riglogix.rigzone.com

RigLogix. (2017b). *RigLogix*. Retrieved from http://riglogix.rigzone.com/downloads/Glossary%208-2016.pdf

RigZone. (2017a). *How Do Jackups Work?* Retrieved March 29, 2017, from RigZone: http://www.rigzone.com/training/insight.asp?insight_id=339

RigZone. (2017b). *How Do Semisubmersibles work?* Retrieved March 29, 2017, from RigZone: http://www.rigzone.com/training/insight.asp?insight_id=338

RigZone. (2017c). *Offshore Rig Status Descriptions*. Retrieved May 9, 2017, from RigZone: http://images.rigzone.com/data/rig_statusdescriptions.asp

RigZone. (2017d). *RigOutlook 2017.* RigZone.

Ringlund, G. B., Rosendahl, K. E., & Skjerpen, T. (2004). *Does oilrig activity react to oil price changes?* Statistics Norway, Research Department.

Schlumberger. (2017). *Blowout preventer*. Retrieved June 12, 2017, from Schlumberger: http://www.glossary.oilfield.slb.com/Terms/b/blowout_preventer.aspx

Tufte, P. A. (2000). *En intuitiv innføring i logistisk regresjon.* Lysaker: Statens Institutt For Forbruksforskning.

Tvedte, M. V., & Sterud, A. (2016). *Obtaining contracts in the North Sea OSV market - A vessel based logit model.* Bergen: Norwegian School of Economics.

U.S. Energy Information Administration. (2017a). *Europe Brent Spot Price FOB (Dollars per Barrel)*. Retrieved April 25, 2017, from U.S. Energy Information Administration: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=RBRTE&f=D

U.S. Energy Infromation Administration. (2017b). *Cushing, OK Crude Oil Future Contract 4 (Dollars per Barrel)*. Retrieved June 3, 2017, from U.S. Energy Infromation Administration: https://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=rclc4&f=m

Wooldridge, J. M. (2016). *Introductory Econometrics - A Modern Approach.* Boston: Cengage Learning.

Appendices

Appendix 1 – Regression results

Table A1.1 Jackups with day rate

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.186	0.0942**	0.130**	0.000537	0.188***	0.0287
	(0.136)	(0.032)	(0.025)	(0.979)	(0.002)	(0.100)
Max Water Depth	0.00999	-0.0306**	-0.00302	0.000409	-0.0156	-0.00758*
	(0.364)	(0.019)	(0.802)	(0.937)	(0.110)	(0.095)
Max Drilling Depth	-0.00000808	0.0000491	0.0000365	-0.0000438	0.000038	-0.0000212
	(0.961)	(0.631)	(0.757)	(0.459)	(0.702)	(0.666)
Quarters Capacity	0.0336	0.0298	0.000318	0.00708	0.0477**	0.0214*
	(0.396)	(0.265)	(0.990)	(0.643)	(0.030)	(0.088)
Variable Deck Load	0.000224	0.00023	0.000110	-0.000106	0.000205**	-0.0000403
	(0.146)	(0.115)	(0.355)	(0.100)	(0.037)	(0.463)
BOP Max		0.00012	0.000146	-0.0000234	0.000575***	0.0000386
		(0.571)	(0.479)	(0.859)	(0.006)	(0.706)
Day Rate	-0.0000738*	-0.0000533***	-0.423****	-0.00195	0.00000606	0.0000104**
	(0.068)	(0.009)	(0.000)	(0.967)	(0.516)	(0.037)
Number Of Rigs	-0.278	-0.0725	0.00000912	0.0000119	-0.301****	0.00386
	(0.139)	(0.523)	(0.735)	(0.423)	(0.000)	(0.925)
Severe Environment	-1.266	2.260*	0.186	0.168	-0.188	0.474
	(0.390)	(0.097)	(0.827)	(0.752)	(0.760)	(0.275)
Constant	-2.027	5.24	-8.186	-2.019	-17.04***	-3.603*
	(0.852)	(0.348)	(0.322)	(0.602)	(0.002)	(0.073)
Observations	206	197	269	251	475	448
McFadden pseudo-R^2	0.2521	0.2093	0.2982	0.0470	0.2702	0.0546

p -values in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

Table A1.2 Semi-submersibles with day rate

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.149	0.0130	0.138**	0.0119	0.229****	0.0560*
	(0.259)	(0.868)	(0.023)	(0.744)	(0.000)	(0.064)
Max Water Depth	-0.000268	-0.00149	-0.000168	-0.0000330	-0.000478*	-0.0000909
	(0.836)	(0.382)	(0.547)	(0.795)	(0.099)	(0.436)
Max Drilling Depth	0.000149	-0.000166	0.000220*	0.0000721	0.000199	-0.00000508
	(0.907)	(0.344)	(0.087)	(0.442)	(0.119)	(0.946)
Quarters Capacity		0.0358	-0.0757**	0.00196	-0.0733**	0.0167
		(0.447)	(0.025)	(0.896)	(0.024)	(0.195)
Variable Deck Load		0.000273	0.000158	-0.0000825	0.000653**	0.0000198
		(0.531)	(0.560)	(0.640)	(0.020)	(0.901)
Number Of Rigs	0.524	0.00866	-0.0229	-0.00296	0.0297	0.00787
	(0.218)	(0.904)	(0.718)	(0.947)	(0.543)	(0.814)
BOP Max	-0.000155	-0.0000547	-0.0000956	0.0000902	-0.0000804	0.0000557
	(0.447)	(0.731)	(0.364)	(0.372)	(0.367)	(0.484)
Day Rate	-0.0000126	0.0000230	-0.0000324***	-0.0000440****	-0.0000360***	-0.0000434****
	(0.817)	(0.501)	(0.005)	(0.000)	(0.002)	(0.000)
Self-Propelled	-0.0982	-0.637	-0.527	0.0583	-0.774*	-0.0124
	(0.916)	(0.433)	(0.269)	(0.882)	(0.079)	(0.970)
DP-2			0.724	1.172	-0.207	0.451
			(0.644)	(0.339)	(0.889)	(0.673)
DP-3			2.199	0.595	3.986***	1.463*
			(0.168)	(0.573)	(0.007)	(0.091)
Severe Environment		-0.579	-0.852	-0.739	-1.028*	-0.472
		(0.584)	(0.153)	(0.161)	(0.085)	(0.272)
Constant	-11.07	-9.942	9.502	12.96***	3.853	10.91**
	(0.755)	(0.586)	(0.232)	(0.009)	(0.611)	(0.019)
Observations	191	184	271	233	462	417
McFadden pseudo-R^2	0.3486	0.1346	0.2370	0.0967	0.2629	0.0898

p -values in parentheses
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

Table A1.3 Jackups with oil futures price

	2010-2013		2014-2017		2010-2017	
	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked	Cold-Stacked	Ready-Stacked
Age	0.171	0.0847*	0.123**	-0.00157	0.158***	0.0253
	(0.156)	(0.089)	(0.019)	(0.941)	(0.004)	(0.151)
Max Water Depth	0.00588	-0.0347**	-0.00203	0.000808	-0.0168*	-0.00743
	(0.577)	(0.012)	(0.868)	(0.880)	(0.084)	(0.114)
Max Drilling Depth	-0.0000345	0.0000389	0.0000251	-0.0000401	-0.00000492	-0.0000274
	(0.826)	(0.712	(0.830)	(0.507)	(0.96)	(0.587)
Quarters Capacity	0.0373	0.0267	-0.00613	0.00318	0.0386*	0.0144
	(0.362)	(0.343)	(0.815)	(0.838)	(0.08)	(0.258)
Variable Deck Load	0.000244	0.00026	0.000102	-0.000112*	0.000213**	-0.0000359
	(0.105)	(0.092)	(0.400)	(0.090)	(0.03)	(0.523)
BOP Max		0.000125	0.000117	-0.0000455	0.000542**	0.0000155
		-0.572	(0.575)	(0.740)	(0.01)	(0.884)
Number Of Rigs	-0.18	-0.0334	-0.440****	-0.0175	-0.0272**	-0.0324****
	(0.304)	(0.77)	(0.00)	(0.714)	(0.01)	(0.00)
Oil Futures Price (4-months)	-0.0674	-0.0975****	-0.0400*	-0.0336****	-0.325****	-0.0376
	(0.164)	(0.001)	(0.055)	(0.001)	(0.000)	(0.366)
Severe Environment	-0.634	2.997**	0.342	0.281	-0.0896	0.646
	(0.654)	(0.039)	(0.694)	(0.607)	(0.889)	(0.155)
Constant	-6.905	6.444	-2.849	2.979	-10.27*	2.018
	(0.487)	(0.287)	(0.595)	(0.238)	(0.074)	(0.344)
Observations	206	197	269	251	475	448
McFadden pseudo-R^2	0.2192	0.2374	0.3357	0.0996	0.3022	0.1180

p -values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

Table A1.4 Semi-submersibles with oil futures price

	2010-2013		2014-2017		2010-2017	
	Cold-stacked	Ready-stacked	Cold-stacked	Ready-stacked	Cold-stacked	Ready-stacked
Age	0.141	0.0163	0.155**	0.0123	0.212****	0.0178
	(0.295)	(0.839)	(0.011)	(0.736)	(0.00)	(0.570)
Max Water Depth	-0.000313	-0.00154	-0.000212	-0.0000134	-0.000447	-0.00000971
	(0.810)	(0.371)	(0.454)	(0.915)	(0.121)	(0.933)
Max Drilling Depth	0.00019	-0.000168	0.000179	0.0000257	0.000157	-0.0000242
	(0.868)	(0.341)	(0.157)	(0.779)	(0.218)	(0.755)
Quarters Capacity		0.0356	-0.0665**	0.00937	-0.0723**	0.0134
		(0.446)	(0.045)	(0.517)	(0.026)	(0.310)
Variable Deck Load		0.000269	0.000238	-0.0000704	0.000659**	-0.0000159
		(0.538)	(0.375)	(0.688)	(0.018)	(0.921)
Number Of Rigs	0.476	0.0114	-0.0299	-0.00919	0.0322	-0.0128
	(0.185)	(0.875)	(0.631)	(0.840)	(0.525)	(0.726)
BOP Max	-0.000156	-0.0000582	-0.0000775	0.000102	-0.000101	0.000037
	(0.450)	(0.714)	(0.451)	(0.313)	(0.263)	(0.653)
Oil Futures Price (4-months)	0.0253	-0.0289	-0.0164	-0.0429****	-0.0247***	-0.0413****
	(0.669)	(0.425)	(0.136)	(0.000)	(0.002)	(0.000)
Self-Propelled	-0.12	-0.628	-0.438	0.105	-0.659	0.00953
	(0.897)	(0.439)	(0.344)	(0.786)	(0.125)	(0.977)
DP-2			0.659	1.128	-0.0984	0.508
			(0.667)	(0.358)	(0.947)	(0.644)
DP-3			2.448	0.555	3.744**	0.453
			(0.122)	(0.598)	(0.013)	(0.618)
Severe Environment		-0.624	-0.867	-0.658	-1.156*	-0.679
		(0.546)	(0.142)	(0.206)	(0.053)	(0.129)
Constant	-18.26	1.673	-3.089	-1.319	-6.491	-0.128
	(0.502)	(0.864)	(0.618)	(0.686)	(0.267)	(0.965)
Observations	191	184	271	233	462	417
McFadden pseudo-R^2	0.3509	0.1365	0.2110	0.0955	0.2640	0.1473

p -values in parentheses

$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$, $^{****}p < 0.001$

Appendix 2 – Correlation matrices

Table A2.1 Jackups 2010-2017 cold-stacked with Day Rate and Oil Futures Price

e(V)	Age	Max WD	Max DD	Quarters Cap.	Variable Deck Load	BOP Max	Day Rate	Oil Futures Price	Number of Rigs	Severe Env.	_cons
StatusCoS											
Age	1										
Max WD	0.0013	1									
Max DD	0.5362	0.2117	1								
Quarters Cap.	0.4005	-0.5544	-0.0285	1							
Variable Deck Load	0.2477	-0.5779	-0.3672	0.2466	1						
BOP Max	0.3549	-0.733	-0.0315	0.6844	0.43	1					
Day Rate	-0.2153	-0.0791	-0.1401	0.0087	-0.0093	-0.0627	1				
Oil Futures Price	-0.001	0.0127	0.0459	0.0997	-0.0459	-0.0213	0.8102	1			
Number of Rigs	-0.0318	-0.2141	0.0816	0.235	-0.1749	0.2179	0.1624	0.2144	1		
Severe Env.	-0.0128	-0.2135	-0.0123	-0.0708	-0.0014	0.005	-0.061	-0.0993	0.2474	1	
_cons	-0.675	0.072	-0.5139	-0.5182	-0.0076	-0.419	-0.4274	-0.5904	-0.2626	0.0964	1

Table A2.2 Jackups 2010-2017 ready-stacked with Day Rate and Oil Futures Price

e(V)	Age	Max WD	Max DD	Quarters Cap.	Variable Deck Load	BOP Max	Number of Rigs	Day Rate	Oil Futures Price	Severe Env.	_cons
StatusRdS											
Age	1										
Max WD	-0.2979	1									
Max DD	0.2923	0.0655	1								
Quarters Cap.	0.3416	-0.4356	-0.2967	1							
Variable Deck Load	0.1503	-0.4638	-0.364	-0.0124	1						
BOP Max	0.4775	-0.6383	0.1418	0.3554	0.0807	1					
Number of Rigs	-0.0663	-0.0612	-0.0271	0.0933	-0.1006	-0.0166	1				
Day Rate	-0.0956	0.0206	-0.0846	0.0099	0.0414	-0.0597	0.0105	1			
Oil Futures Price	-0.0388	0.0301	-0.0101	0.0759	0.0033	0.0021	0.157	0.8117	1		
Severe Env.	-0.0158	-0.3016	-0.1785	-0.2124	0.2782	-0.1876	0.1141	-0.063	-0.1245	1	
_cons	-0.4578	0.0864	-0.3564	-0.3105	0.149	-0.3924	-0.1268	-0.6664	-0.7176	0.3316	1

Table A2.3 Semi-submersibles 2010-2017 cold-stacked with Day Rate and Oil Futures Price

e(V)	Age	Max WD	Max DD	Quarters Cap.	Variable Deck Load	Number of Rigs	BOP Max	Day Rate	Oil Futures Price	Self-Propelled	DP or Moored	DP-2 or DP-3	Severe Env.	_cons
StatusCoS														
Age	1													
Max WD	-0.4213	1												
Max DD	0.1681	-0.1655	1											
Quarters Cap.	0.1415	-0.3124	-0.1312	1										
Variable Deck Load	0.4387	-0.5223	-0.2011	-0.1349	1									
Number of Rigs	0.2306	-0.1446	0.0301	0.4767	-0.1974	1								
BOP Max	0.2538	-0.0953	-0.0377	0.238	-0.1208	0.0438	1							
Day Rate	0.1386	-0.0744	-0.1194	0.1411	0.1239	-0.0701	0.1202	1						
Oil Futures Price	0.2279	-0.105	0.0034	0.0924	0.1178	-0.0969	0.188	-0.0606	1					
Self-Propelled	-0.1793	0.1794	0.0159	0.1796	-0.3915	0.0912	0.163	0.0631	-0.0423	1				
DP or Moored	-0.006	0.1352	0.3428	0.1488	-0.4866	0.284	-0.0165	-0.0193	-0.0601	0.0772	1			
DP-2 or DP-3	0.6556	-0.608	-0.0879	0.2144	0.3245	0.3472	0.1247	0.0658	0.1116	-0.2242	0.0577	1		
Severe Env.	0.0755	-0.0153	0.2492	0.2131	-0.4332	0.3481	0.1928	0.0334	0.0924	0.0269	0.1414	-0.0632	1	
_cons	-0.6275	0.4646	-0.2677	-0.5161	-0.2477	-0.2441	-0.3601	-0.6614	-0.1816	-0.0275	-0.0853	-0.3599	-0.1876	1

Table A2.4 Semi-submersibles 2010-2017 ready-stacked with Day Rate and Oil Futures Price

e(V)	Age	Max WD	Max DD	Quarters Cap.	Variable Deck Load	Number of Rigs	BOP Max	Day Rate	Oil Futures Price	Self-Propelled	DP or Moored	DP-2 or DP-3	Severe Env.	_cons
StatusRdS														
Age	1													
Max WD	-0.367	1												
Max DD	-0.0755	-0.1833	1											
Quarters Cap.	0.2844	-0.0916	-0.18	1										
Variable Deck Load	0.1705	-0.4786	-0.4594	-0.3267	1									
Number of Rigs	0.278	-0.0005	0.0249	0.375	-0.3066	1								
BOP Max	0.2438	-0.2609	-0.1396	0.4025	-0.0056	0.0441	1							
Day Rate	0.1012	-0.0573	-0.1048	0.1326	0.0785	-0.0331	0.0367	1						
Oil Futures Price	0.26	-0.14	-0.039	0.1175	0.0818	0.0793	0.0649	-0.0405	1					
Self-Propelled	-0.0149	0.0634	0.1152	0.183	-0.336	0.0575	0.0973	0.0023	-0.0027	1				
DP or Moored	0.001	0.18	0.3565	0.1827	-0.5253	0.2698	-0.0485	-0.0474	-0.0464	0.0353	1			
DP-2 or DP-3	0.8407	-0.3868	-0.1406	0.1554	0.1589	0.3033	0.2293	0.0768	0.2285	-0.0867	0.0719	1		
Severe Env.	0.2392	0.0039	0.2555	0.2187	-0.3861	0.3574	-0.0629	0.1273	0.1705	0.0398	0.0973	0.0215	1	
_cons	-0.4913	0.3884	-0.1193	-0.4442	-0.012	-0.1754	-0.3873	-0.7859	-0.1809	-0.0756	-0.0503	-0.3594	-0.2767	1

Appendix 3 – Variance inflation factor test

Table A3.1 Jackups 2010-2017 cold-stacked with Day Rate and Oil Futures Price

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Age	2.98	1.73	0.3351	0.6649
Max WD	6.73	2.59	0.1486	0.8514
Max DD	3.62	1.9	0.2764	0.7236
Quarters Cap.	4.24	2.06	0.2357	0.7643
Variable Deck Load	3.33	1.82	0.3007	0.6993
BOP Max	3.55	1.88	0.2818	0.7182
Number of Rigs	1.09	1.04	0.9174	0.0826
Severe Env.	2.74	1.65	0.3656	0.6344
Day Rate	2.45	1.57	0.4082	0.5918
Oil Futures Price	2.41	1.55	0.4141	0.5859
Mean VIF	3.31			

Table A3.2 Jackups 2010-2017 ready-stacked with Day Rate and Oil Futures Price

Variable	VIF	SQRT VIF	Tolerance	R-Squared
Age	3.04	1.74	0.3284	0.6716
Max WD	7.06	2.66	0.1416	0.8584
Max DD	3.74	1.93	0.2671	0.7329
Quarters Cap.	4.45	2.11	0.2245	0.7755
Variable Deck Load	3.57	1.89	0.2801	0.7199
BOP Max	3.92	1.98	0.2553	0.7447
Number of Rigs	1.12	1.06	0.895	0.105
Severe Env.	2.84	1.68	0.3522	0.6478
Day Rate	2.41	1.55	0.4154	0.5846
Oil Futures Price	2.39	1.55	0.4182	0.5818
Mean VIF	3.45			

Table A3.3 Semi-submersible 2010-2017 cold-stacked with Day Rate and Oil Futures Price

Variable	VIF	SQRT VIF	Tolerance	R-squared
Age	7.55	2.75	0.1324	0.8676
Max WD	6.63	2.57	0.1508	0.8492
Max DD	4.96	2.23	0.2017	0.7983
Quarters Cap.	4.5	2.12	0.2222	0.7778
Variable Deck Load	8.64	2.94	0.1157	0.8843
BOP Max	1.41	1.19	0.7085	0.2915
Number of Rigs	1.69	1.3	0.5904	0.4096
Day Rate	1.12	1.06	0.8954	0.1046
Oil Futures Price	1.16	1.08	0.8621	0.1379
Self-Propelled	1.51	1.23	0.6635	0.3365
DP or Moored	7.8	2.79	0.1282	0.8718
Severe Env.	2.43	1.56	0.4116	0.5884
Mean VIF	4.12			

Table A3.4 Semi-submersible 2010-2017 ready-stacked with Day Rate and Oil Futures Price

Variable	VIF	SQRT VIF	Tolerance	R-squared
Age	7.31	2.7	0.1367	0.8633
Max WD	6.51	2.55	0.1535	0.8465
Max DD	5.12	2.26	0.1953	0.8047
Quarters Cap.	4.6	2.14	0.2176	0.7824
Variable Deck Load	8.84	2.97	0.1131	0.8869
BOP Max	1.39	1.18	0.7186	0.2814
Number of Rigs	1.64	1.28	0.6082	0.3918
Day Rate	1.11	1.05	0.8988	0.1012
Oil Futures Price	1.15	1.07	0.8696	0.1304
Self-Propelled	1.52	1.23	0.6586	0.3414
DP or Moored	7.69	2.77	0.13	0.87
Severe Env.	2.42	1.56	0.4132	0.5868
Mean VIF	4.11			