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Obtaining contracts in the North Sea OSV market

A vessel based logit model

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Master thesis in Finance

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Abstract

This thesis studies the determinants for obtaining contracts in the North Sea offshore supply market from 2007 to 2016. We specify a logistic regression model to investigate the effect of vessel specifications on the probability of obtaining a contract for Offshore Support Vessels (OSV). The model investigates the differences in vessel design and specification preferences between the term and spot market for Platform Supply Vessels (PSV) and Anchor Handling Tug Supply (AHTS) vessels.

We find that the determinants for obtaining contracts in the PSV segment coincide, as younger and medium complex vessels, with large clear deck area built in Northwest Europe, are more likely to obtain contracts in both markets. The probability of obtaining contracts in the spot market is more sensitive to vessel specifications, compared to the term market. In addition, having the preferred set of technical specifications is the most important determinant in both markets.

We find that the preferences for AHTS vessel specifications are significantly diversified when comparing the term and spot market. While younger, complex and more powerful vessels have a higher probability of obtaining spot contracts, the term market is a two-tier market where either a less powerful and less complex vessel, or a more powerful and more complex vessel, is required to obtain contracts. Technical specifications are the most important determinants, particularly in the spot market, while the age and size of the vessel is less important.

This thesis provides a basis for further research, such as investigating the determinants within vessel classes or studying the recent OSV market after the 2014 downturn into detail. Furthermore, applying the logistic regression model to the drilling rig industry could prove to be an interesting field of study.

The findings may be of interest for shipowners when deciding on fleet expansion or renewal, and in the lay-up decision. In addition, investors and banks can use the findings to evaluate which shipowning companies to invest in or grant loans to, by assessing a fleet's probability of obtaining contracts. Finally, the model could be used as a tool for shipbrokers to evaluate which types of vessels that are most preferred in the North Sea.

This thesis supplements the limited existing literature on the North Sea offshore industry as it searches for the determinants for obtaining a contract, rather than the freight rate determinants which have been studied before.

Preface

This master thesis is written as a concluding part of our Master of Science in Economics and Business Administration at NHH - Norwegian School of Economics, within our major in Finance.

The offshore oil and gas production in the North Sea has been a booming industry for Norway as a country and for companies that participate in the offshore market. The decreasing crude oil price during the last years has been challenging for the market, leading to cost cuts, sustained low day rates and consolidation in the offshore business. We wanted to contribute to the sparse selection of existing research, and to gain a deeper knowledge about an industry which is the main driver for economic growth in Norway. From earlier courses within shipping and offshore at NHH we have gained insight in the offshore industry, which inspired us to further develop our understanding and to contribute to the existing research. With valuable help from our supervisor, we believe that we have found a relevant topic which may be of interest to various participants in the offshore market.

We would like to give special thanks to our supervisor, Roar Os Ådland, for interesting discussions, sharing his extensive knowledge and giving constructive feedback throughout the writing process. In addition, we would like to thank Clarksons Platou Offshore Research and Ulstein International for sharing their detailed datasets and for giving useful advice and knowledge about the offshore supply market. We would also like to thank Siri Strandenes Pettersen at NHH and Amir Alizadeh at Cass Business School for valuable guidelines regarding the modelling of our dataset. Finally, we are grateful for receiving grants from The Norwegian Ship Owners' Association's Fund at NHH.

We hope that our work will be of relevance for participants in the North Sea offshore market, and that it may inspire further research within the field.

Bergen, December 2016

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1. Introduction

The North Sea offshore supply market is highly volatile, with large fluctuations observed in day rates over time. Historically, the market has been strong in terms of yielding high day rates. However, the recent drop in oil prices, combined with a substantial oversupply of vessels, has led to challenging market conditions characterized by vessel idleness, increased lay-up and significantly lower day rates.

While day rate levels serve as the common perception of the market condition, this thesis argues that market utilization is a determining factor as well. This misconception is shown by the deviation between the unemployment adjusted earnings (UAE) and Clarksons Platou's Day Rate Index (CP Index) for the largest Platform Supply Vessels and Anchor Handling Tug Supply vessels operating in the North Sea spot markets in Figure 1. Thus, combining day rates and the market utilization provides a more realistic insight to the actual market condition. Being successful in the North Sea offshore supply market seems highly dependent on vessel utilization, and this serves as a motivation for the thesis.

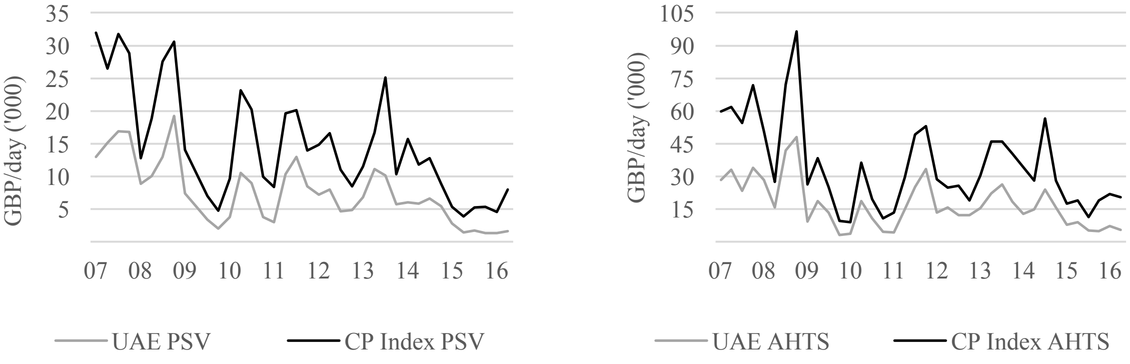

Figure 1: Unemployment adjusted earnings and Clarksons Platou Dayrate Index for PSV 900+ m^2 spot market and AHTS 20,000+ bhp spot market

The objective of this thesis is to identify how vessel design and specifications impact the probability of obtaining a contract, and thus the utilization, in the North Sea offshore supply markets from 2007 to 2016. Furthermore, to reveal potential differences in the determinants for obtaining contracts, the analyses are conducted for each vessel segment and contract type. Finally, this thesis seeks to identify whether the preferred vessel specifications have changed recently, compared to the ten-year period. By utilizing a logit model, we analyse how different vessel specifications serves as determinants for obtaining contracts, both in a historical and recent perspective.

In a challenging and competitive industry such as the North Sea offshore supply market, it is imperative to be aware of the market drivers and how these can be exploited to each participant's best interest. By gaining deeper knowledge about the determinants for obtaining a contract, shipowners operating in the North Sea can get a better understanding of what kind of vessels that will contribute to increased utilization. Furthermore, the results are useful for shipbrokers, banks, investors, and shipyards. Findings from this thesis can be used as a tool for shipbrokers to evaluate which types of vessels that are the most preferred in the North Sea. Further, banks and investors can assess shipowners' financial strength through observing the prospect of future cash flow based on contract coverage. Additionally, yards can better distinguish between suitable and less suitable vessel specifications in regards of shipbuilding.

This thesis is structured in five sections. Following the introduction, Section 2 reviews literature on offshore supply vessels in the North Sea market. Section 3 presents background information on the North Sea offshore market, while Section 4 explains the data methodical framework. Estimation results, discussion of the analyses and probability estimations of the models are presented in Section 5. Finally, Section 6 contains concluding remarks and suggestions for further research.

2. Literature review

The literature on the offshore industry is limited, but some studies have searched for freight rate determinants in the offshore spot and term market. As far as we know, investigating the determinants for obtaining contracts has not yet been done.

Dahle and Kvalsvik (2016) investigate the microeconomic determinants of freight rates in the global OSV market, and find multiple significant determinants such as vessel size, vessel age and operating region. The authors also find vessel-specific properties such as a DP2 system and ice classification to be significant determinants of OSV freight rates. However, the two OSV segments are not divided into size categories, preventing the authors from revealing potential differences in determinants for freight rates within the PSV and AHTS segments. To be able to uncover such potential differences in our research, we utilize the size categories commonly used by offshore analysts.

Ringlund et al. (2008) investigate how oilrig activity in different non-OPEC regions is affected by the crude oil price, and find a positive relationship between oil rig activity and the crude oil price. The increasing complexity and size of the offshore rigs in the North Sea has further led to increased demand for larger and more complex OSVs. To see if Ringlund et al. are correct, we investigate whether the more complex OSVs in the North Sea have a higher probability of obtaining a contract.

The OSV is one of the largest cost elements in the upstream supply chain of oil and gas companies, and Aas et al. (2009) perform a logistical analysis of OSVs on the Norwegian continental shelf, establishing carrying capacity, sailing, loading and unloading capabilities as the main features of an OSV. We will look at the effect of carrying capacity for PSVs, by including the clear deck area in the analysis. The sailing capability of a vessel is represented and studied in our analysis by including variables for the DP systems. Furthermore, the article discusses the complexity of designing the optimal supply vessel for the Norwegian continental shelf. As our thesis seeks to identify the specifications that make a North Sea OSV more likely to obtain a contract, we will try to find the optimal PSV and AHTS vessel design for the North Sea through our analysis.

Alizadeh et al. (2016) use a vessel based logit model to investigate the vessel specific and macroeconomic determinants that affect the probability for scrapping dry bulk ships. They find that the probability of scrapping a dry bulk ship increases with age, interest rates, freight market volatility and scrap steel prices. The logistic regression model of this paper is the inspiration for our own model, as we have a similar binary dependent variable.

Another application of a limited dependent variable regression model in shipping can be found in an article by Talley (1999). The author uses tobit estimation to investigate the determinants of oil spillage and property damage costs in oil tanker accidents, and finds that fire and explosion incur the largest damage cost to vessels, but also the lowest oil spillage cost. Furthermore, the article finds that grounding accidents by oil tankers incur the smallest vessel damage cost, but the largest oil spillage cost, and that US flagged tankers are associated with the lowest oil spillage costs.

Following the article by Talley (1999), Jin, Talley and Yip (2011) study the effectiveness of ship hull design in reducing marine pollution by using a tobit regression model to investigate the size of oil spillage due to oil-cargo vessel accidents. The authors find that a double hull design can reduce the size of oil spills by as much as 62 % in oil tanker accidents.

The estimation of the tobit model in both articles is done by Maximum Likelihood Estimation (MLE), similar to the logit model, but the dependent variable is a corner solution response rather than a binary response.

A more recent research by Grøvdal and Tomren (2016), utilizes both OLS and logit models to study the determinants affecting lay-up probability in the OSV market. Using OLS, the authors find that day rates for OSVs are negatively correlated with lay-up levels. However, they note that there might exist a time lag for this effect. By using logistic regression, the thesis finds that clear deck area for PSVs and bollard pull for AHTS vessels, are negatively correlated with lay-up levels for the two segments. However, the authors include rather few vessel specific variables in the analyses, thus limiting the findings to general size variables only.

The intended contribution of our research to the literature is threefold: a) our findings allow market participants to better assess a vessel's probability of obtaining a contract, b) we investigate the actual vessel specific determinants for obtaining a contract, rather than explaining vessel specifications' effect on day rates and c) we prove that there exist significant differences in determinants across vessel segments and markets.

3. The offshore industry in the North Sea

The OSVs are a key part of the upstream supply chain, and provide support services for exploration, development and production activities in the offshore oil and gas sector. The two most important kinds of OSVs in the North Sea are PSVs and AHTS vessels.

PSVs are designed to transport supplies and equipment from onshore locations to offshore installations, and the clear deck area of a PSV is often used to group the vessels by size. In addition, PSVs have under-deck tanks and are able to carry bulk cargo like mud and drillwater. AHTS vessels are used to tow offshore installations and their anchors into position, and the bollard pull (BP) of the vessel is a measure of its pulling power in tonnes. These vessels are more powerful than the PSVs and are classified by brake horsepower (BHP). Increased use of pre-lay mooring in the North Sea has contributed to higher demand for powerful AHTS vessels. Furthermore, the OSVs have to operate close to the installations when performing their tasks, and may have a Dynamic Positioning (DP) system installed to reduce the chance of collisions (ICS, 2011). While a DP1 system is regarded as a simple feature, a DP2 system increases the complexity of a vessel.

One of the largest cost elements in shipping is the fuel cost, and fuel efficiency is important for the charterers since they pay for the fuel. Hence, OSVs with low fuel expenditure are attractive to charterers. More remote oil and gas fields have resulted in larger vessels that can withstand ice, carry more cargo and have greater engine power to be able to operate safe and efficiently. Ice classified vessels have a reinforced hull and can sail in ice covered areas, such as the potential new fields in the Barents Sea (Olje- og Energidepartmentet, 2016).

OSVs equipped with a Remotely Operated Underwater Vehicle (ROV) are considered to be complex vessels, and are used for subsea operations on the fields. The cost of installing subsea equipment has decreased sharply in recent years, due to a rapid technological progress, increasing the demand for ROV capable vessels (Osmundsen, 2011). Further, OSVs with helidecks are able to receive personnel and equipment transported by helicopter, and thus reduce the number of trips from fields to onshore locations. In addition, an OSV may be constructed with a moonpool, which is a hole in the hull of the vessel providing access to calm sea. Helideck and moonpool features are predominantly suitable for AHTS vessels due to their operational tasks. Further, offshore oil and gas production can be dangerous, as the risk of fire is constantly present. Therefore, an OSV may also be equipped with firefighting systems (FIFI) to be able to assist platforms if a fire should break out. FIFI capability is considered as a less complex feature for OSVs.

Overall, both PSVs and AHTS vessels can be characterized by the vessel design and several sophisticated technical specifications, to serve their purpose for operations in the North Sea. Due to the increasing demand for larger and more complex vessels, in addition to attractive outlooks for profits, a large number of new vessels entered the market between 2009 and 2015. Shipowners strive to obtain a high utilization for their vessels, and the recent growth in fleet size shown in Figure 2 and 3 has significantly increased the competition for a high utilization recently.

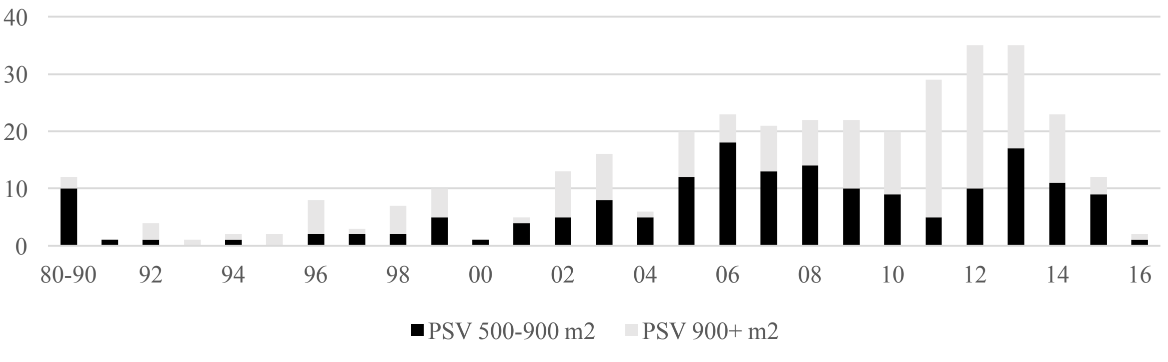

Figure 2: Delivered PSV newbuildings per year with operations in the North Sea

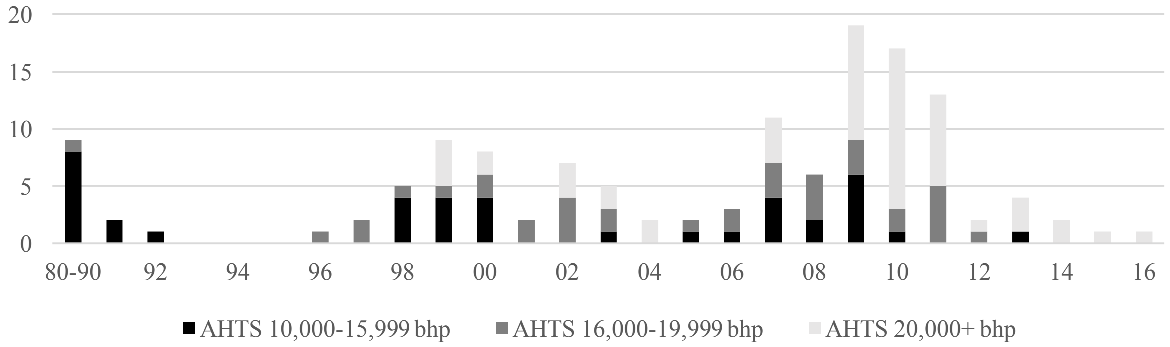

Figure 3: Delivered AHTS newbuildings per year with operations in the North Sea

4. Data and methodology

4.1 The logistic based OSV model

The indicator of whether a vessel is fixed or not is the dependent binary variable. An OSV's ability to obtain a contract is a function of its specifications and fuel expenditure, as well as the market condition.

The specifications used in the econometric model are chosen based on conversations with market participants and in accordance with econometric principles[1]. We find that the various size variables for OSVs in the dataset are closely correlated. Therefore, we only include one size variable for PSVs and AHTS vessels, respectively. Thus, we end up with age, one vessel size proxy for each segment, additional vessel specification variables and adjust for the market condition, and write:

$$V_{i,t} = f\left(age_{i,t}, size_{i,} bulkcap_i, fexp_i, dp_i, ic_i, rov_i, fifi_i, heli_i, moon_i, nwe_i, utilization_t\right) \qquad (1)$$

where the binary variable, $V_{i,t}$, will be equal to 1 if vessel i is fixed at a given day t and equal to 0 if the vessel is unemployed, $age_{i,t}$ is the age of the vessel i, at time t, and $size_i$ is the clear deck area, $deck$, for PSV i, or brake horsepower, bhp, for AHTS i. Further, $bulkcap_i$ is a

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[1] Multicorrelation within vessel characteristics, i.e. clear deck area is closely correlated with length overall and deadweight tonnage, while brake horsepower (bhp) is closely correlated with bollard pull, length overall, and deadweight tonnage.

proxy[2] for the vessel's total under-deck capacity, $fexp_i$ measures the deviation in a vessel's daily fuel expenditure compared to the fleet average[3], while dp_i indicates which dynamic positioning system a vessel has. Further, $ic_i, rov_i, fifi_i, heli_i, moon_i$ and nwe_i are dummy variables indicating whether vessel i has ice classification, a ROV, firefighting capability, helideck, moonpool or is built in Northwest Europe, respectively. Lastly, $utilization_t$ is a market proxy reflecting the market utilization at day t for the PSV and AHTS segment, respectively. Vessel utilization is computed as the proportion of employed vessels relative to the total supply of vessels in the market at any given day. Utilization reflects the real market state, as a weak OSV market will be characterized by many unemployed vessels, while nearly all vessels will be employed in a strong market. This suits the model, as we aim to find the determinants affecting the probability of obtaining a contract, rather than the determinants for day rates. Thus, the model will be able to analyse whether the estimates differ due to the different ratio of available vessels charterers can choose between in the market.

This thesis relies on discussions with market participants when forming the hypothesis, as there are few empirical frameworks to depend on. Overall, it has been hypothesized that the size and complexity of vessels are significant determinants for obtaining contracts, and that determinants do not vary when comparing the term and spot market. A common perception is that vessels offering higher complexity is especially rewarded in the recent weak markets.

However, there is no clear consensus as to what vessel specifications that increases the probability of obtaining contracts. There is a broad understanding that the largest vessels are strongly preferred in both the PSV and AHTS segment. The age of the vessel is seemingly not an important determinant, indicating that the operational capability is independent of age. Furthermore, having a DP2 system is required, due to the harsh environment in the North Sea. Although some PSVs are equipped with a ROV, the feature is only considered important for AHTS vessels as it fits their scope of work better. As stated, fuel expenditure is a substantial cost element, thus both shipowners and charterers emphasize the importance of vessels yielding low fuel costs. On the contrary, it has been argued that fuel costs have been of less importance due to booming periods, and that it will be regarded more determining going forward due to Statoil's "Sustainable Shipping Strategy" (Statoil, 2011).

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[2] A bulkcapacity proxy has been implemented in cooperation with Ulstein International, equal to the sum of total mud tank and drillwater tank capacity.

[3] The fuel expenditure formula is based on Aadland et al. (2017).

Opinions vary significantly for whether having ice classification increases the probability of obtaining contracts. On one hand, ice classified vessels are considered more complex and flexible, thus increasing the preference for such vessels. On the contrary, the reinforced hull may cause a vessel's fuel consumption to increase, inferring that ice classification should decrease the probability of obtaining contracts. As a result, we do not include ice classification to the hypotheses but investigate the effect of ice classified vessels in the analysis, aiming to clarify the importance of this factor.

Although most fields in the North Sea have standby vessels dedicated to deal with fires and other accidents, some charterers are required to contract additional vessels with firefighting capabilities for safety reasons. Thus, PSVs providing this feature should be rewarded. Further, some shipowners emphasize the importance of large bulk capacity for PSVs. However, it has been claimed that this is not a clear determinant, as the bulk tank requirements are highly dependent on whether the scope of work is production or drilling support, which have significantly varying bulk tank requirements.

Overall, having a complex vessel seems to be advantageous for operations in the North Sea, especially in the AHTS segment. This view has been strengthened in recent years, as operators are able to contract highly complex vessels at low day rates due to the market oversupply. As a result, our hypotheses are:

1. *Large clear deck area, DP2 system, ROV, FIFI capability, large bulk capacity, low fuel expenditure and low vessel age will make a PSV more likely to obtain a contract.*

2. *Powerful engine, DP2 system, ROV, low fuel expenditure, and low vessel age will make an AHTS vessel more likely to obtain a contract.*

3. *Vessels with higher complexity are preferred in the recent weak markets.*

Table 1: Answers from market participants' questionnaire[4]

	Age	Large clear deck area	Powerful vessel	Large bulk capacity	DP2	ROV	Ice class	Fuel efficiency	FIFI	Low emissions	Skill of crew	HSEQ record
PSV												
Shipowner avg.*	17 %	100 %	-	50 %	100 %	33 %	17 %	67 %	17 %	50 %	50 %	33 %
Other participants avg.*	0 %	100 %	-	33 %	100 %	0 %	67 %	33 %	33 %	0 %	33 %	33 %
Total*	**11 %**	**100 %**	**-**	**44 %**	**100 %**	**22 %**	**33 %**	**67 %**	**22 %**	**33 %**	**44 %**	**33 %**
AHTS												
Shipowner avg.*	17 %	33 %	83 %	-	83 %	17 %	0 %	83 %	-	50 %	50 %	33 %
Other participants avg.*	0 %	100 %	100 %	-	100 %	67 %	0 %	0 %	-	0 %	33 %	33 %
Total*	**11 %**	**56 %**	**89 %**	**-**	**89 %**	**33 %**	**22 %**	**56 %**	**-**	**33 %**	**44 %**	**33 %**

- * % of participants denoting the feature as important for obtaining a contract

As the dependent variable is a binary variable, we specify a logistic regression model in order to investigate what vessel specific factors that affect an OSV's probability of obtaining a contract. The model is specified according to econometric principles[5]. Initially we specify and estimate a logit model for each year of the sample, and for each vessel segment. This is done for both the spot and term market. The initial model is thus an annual logit model, based on vessel specific variables for age, size, fuel expenditure and technical specifications. The models are specified in the following form for PSVs (Eq. 2) and AHTS vessels (Eq. 3):

$$Pr(V_{i,t}=1|\Omega_t)=\frac{1}{1+e^{-(\beta_0+\beta_1 age_i+\beta_2 deck_i+\beta_3 bulkcap_i+\beta_4 fexp_i+\beta_5 dp_i+\beta_6 ic_i+\beta_7 rov_i+\beta_8 fifi_i+\beta_9 nwe_i)}} \tag{2}$$

$$Pr(V_{i,t}=1|\Omega_t)=\frac{1}{1+e^{-(\beta_0+\beta_1 age_i+\beta_2 bhp_i+\beta_3 fexp_i+\beta_4 dp_i+\beta_5 ic_i+\beta_6 rov_i+\beta_7 fifi_i+\beta_8 heli_i+\beta_9 moon_i+\beta_{10} nwe_i)}} \tag{3}$$

where $Pr(V_{i,t}=1|\Omega_t)$ is the probability of vessel *i* being contracted on day *t*, given its set of specifications indicated by Ω_t. The estimation of the logit model is done by maximum likelihood estimation, and the logit function ensures that the estimated probabilities are in the 0 to 1 range. Furthermore, we pool the ten-year data and estimate a balanced panel logit model

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[4] The dataset provides no data on the skill of crew, the HSEQ record and the vessels' emission level. Thus, these factors are omitted from the hypotheses, and we solely focus on the measurable specifications available.

[5] The model controls heteroscedasticity for it by using cluster-robust standard errors. Further, to avoid multicollinearity, a variance inflation factor test is examined (Appendix 3) in combination with correlation matrices (Appendix 2) to ensure that the models comply with econometric assumptions, and produce robust estimates.

based on Eq. 4 for PSVs and Eq. 5 for AHTS vessels. The panel logit models include the market utilization variable in addition to the vessel specific variables. To capture the variations within each vessel class, we extend the analysis by specifying a corresponding model for both PSV classes and the three AHTS classes. Additionally, to investigate whether the determinants have changed due to the recent market turmoil, we specify a similar panel logit model, pooling the years 2015 and 2016. Hence we write:

$$Pr(V_{i,t} = 1|\Omega_t) = \frac{1}{1 + e^{-(\beta_0+\beta_1 age_i+\beta_2 deck_i+\beta_3 bulkcap_i+\beta_4 fexp_i+\beta_5 dp_i+\beta_6 ic_i+\beta_7 rov_i+\beta_8 fifi_i+\beta_9 nwe_i+\beta_{10} utilization_t)}} \tag{4}$$

$$Pr(V_{i,t} = 1|\Omega_t) = \frac{1}{1 + e^{-(\beta_0+\beta_1 age_i+\beta_2 bhp_i+\beta_3 fexp_i+\beta_4 dp_i+\beta_5 ic_i+\beta_6 rov_i+\beta_7 fifi_i+\beta_8 heli_i+\beta_9 moon_i+\beta_{10} nwe_i+\beta_{11} utilization_t)}} \tag{5}$$

where $Pr(V_{i,t} = 1|\Omega_t)$ is the probability of vessel *i* being contracted on day *t*, given its set of specifications indicated by Ω_t, and $utilization_t$ denotes the market utilization at day *t* for the segment vessel *i* is operating in.

4.2 Description of the data set

The information utilized in this thesis is sourced from ODS-Petrodata and Clarksons Platou Research Ltd[6]. Both sources provide extensive data for 20,454 OSV fixtures in the North Sea for the period January 2007 to July 2016, in addition to detailed specification data for each vessel. A vessel specification overview has been developed based on the sources, providing a range of vessel specific information including age, size and measurements of technical specifications. All specification variables, including explanation and expected sign, are summarized in Appendix 2. The fixture data contains the start and end date for all contracts, as well as contract specific data such as operating region, contract type and day rates.

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[6] Clarksons World Fleet Register (Clarksons, 2016) has also been utilized

The model accounts for a vessel's delivery day from the yard and exclude vessels being demolished, as well as all vessels without DP-systems[7]. As OSVs may move between different operating regions around the world, we have collected the sailing time used by analysts for vessel moves between relevant operating regions[8]. We have included these sailing times in the dataset, and thus exclude a vessel from the model when it is sailing between regions. The North Sea fleet is, in line with market participants' perception, divided into two PSV classes based on clear deck area and three AHTS classes based on engine power[9]. Each vessel can operate in two market segments, the spot and term market. Further, we apply some important assumptions to the model: (a) a given vessel on a term contract is excluded from the spot market model[10], (b) a given vessel on a spot contract is excluded from the term market model, (c) a given vessel contracted in a region other than the North Sea is excluded from both the term and spot market model, (d) vessels in lay-up are included in the model.

Including laid up vessels in the model will give a more precise picture of the supply side in the market. Shipowners will send vessels to lay-up if they do not obtain contracts, in other words these vessels are perceived as unattractive in the market at the time. Including laid up vessels will thus give a more precise picture of the attractive vessels, and enables the model to distinguish between vessel specifications regardless of shipowners' lay-up decision. Another reason for including the laid up vessels is that some market participants emphasize that laid up vessels still compete for term contracts, as long as there is sufficient time to get the vessel out of lay-up before the contract commences.

The statistics of vessel specifications for the PSV fleet are reported in Table 2. There is a significant increase in number of vessels across both classes between 2007 and 2016, from 67 and 53 for the small and large PSV classes to 148 and 165, respectively. The significant newbuilding activity in the OSV market has kept the average vessel age more or less constant over the last ten-year period. However, the larger PSV segment dominates in terms of fleet growth. This is in line with findings from Figure 2, indicating that a large proportion of newer PSVs have a deck size exceeding 900 m^2, and supported by the increasing average deck size

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[7] Vessels without a DP-system are viewed by market participants as "not representative" for the North Sea.

[8] NS to Brazil: 23 days, NS to West Africa: 20 days, NS to Southeast Asia: 35 days, NS to Mediterranean: 11 days

[9] PSV 500-900 m^2 and PSV 900+ m^2, AHTS 10,000-15,999 bhp, AHTS 16,000-19,999 bhp and AHTS 20,000+ bhp

[10] 12 % and 7 % of all spot fixtures for PSVs and AHTS vessels, respectively, are relets of vessels on term contracts.

throughout the years. The larger deck size seems to further result in higher bulk capacity.

Further, a clear trend can be seen towards more complex vessels. This is supported by the 11 percentage point increase in proportion of DP2 systems going from 2007 to 2016, driven by the smaller vessel class as all large PSVs have DP2. In addition, significantly more vessels have ice classification and firefighting capability, while the proportion of vessels with ROV has been kept low and steadily decreased in the later years. This is in line with market participants' perception that PSVs with ROV are regarded as unnecessary advanced. The proportion of Northwest European (NWE) built vessels in the fleet has declined by 12 percentage points from 83 % in 2007, indicating that more foreign built vessels have entered the market. Table 2 indicates that the average daily fuel expenditure has decreased for both PSV classes in recent years, in line with the declining bunker price. However, while the average daily fuel consumption in the large vessel class has decreased over the ten-year period, indicating that the new vessels are more fuel efficient, the average daily fuel consumption for the smallest vessels remains unchanged.

Observing the statistics of vessel specifications for the AHTS fleet, reported in Table 3, it seems that a shift towards larger vessels is evident for this segment as well. The fleet has grown significantly between 2007 and 2016, from 21, 16 and 13 small, medium and large vessels to 26, 24 and 41, respectively. Vessels with more than 20,000 bhp dominate the growth, as seen in Figure 3, which further increases the average bhp throughout the years. While the largest vessel class is dominated by young vessels, the smaller vessel classes consist of mostly older vessels.

Table 3 shows that DP2 systems dominate the fleet. However, the DP system type seems to depend on vessel size, as the smaller vessel classes are more diversified in terms of DP1 and DP2, while the largest vessels all have DP2. Although helideck and moonpool capabilities also seem dependent on vessel size, as only the largest vessel class have these features, the proportion of vessels with helideck and moonpool has steadily declined from 2007 to 2016. Further, the recent alleged trend in preference towards AHTS vessels with ROV is somewhat supported by the 12 percentage point increase in vessels with ROV, from 17 % in 2007. This growth is driven by the largest vessel class alone, as no vessels in the two smaller classes have ROV. Additionally, the number of vessels with ice classification has increased by nine percentage points, from 54 % in 2007. Thus, 29 % of AHTS vessels can offer ROV services in the North Sea, while 63 % can operate in ice prone areas. The proportion of AHTS vessels with firefighting capability has remained stable at 50 % for the total fleet, as it has increased significantly for the medium vessel class while a decrease is evident in the largest vessel class. As for the PSV segment, the proportion of vessels built in NWE has declined, demonstrating the increased competition in the market from vessels built in other regions. The average daily fuel consumption has increased for the two largest vessel classes, and may be explained by the increase in average bhp in both classes. The smallest vessel class has seen a decrease in average bhp, which further reduce the average daily fuel consumption of the vessels. In addition, average daily fuel expenditure has decreased for all classes recently. While this is in line with the declining bunker price, it may also infer that the new and powerful vessels are more fuel efficient.

Overall, the average AHTS vessel has increased its degree of complexity over the ten-year period. However, this is only evident for the medium and large vessel class, as the smallest vessels seem to have a quite similar degree of complexity in 2007 and 2016.

Table 4 and Figure 4 show the PSV market condition for the ten-year period, through the development of the utilization rate. The utilization rates have been significantly high going from 2007 to 2015, with some extreme spikes as a result of a highly volatile spot market. The recent decrease in activity in the North Sea, starting in the fall of 2014, has resulted in a 24 percentage point decrease in PSV utilization when comparing 2014 and 2016. The smaller vessels have had a bigger drop in utilization rates than the larger vessels. The utilization in the spot market is seemingly lower than expected, even in strong markets. Further, Figure 5 provides an overview of the employed and unemployed PSVs, with employment split into spot and term contracts. It is evident that a large majority of the vessels operate in the term market, but that the proportion is decreasing. However, spot contracts account for approximately 80 % of total fixtures.

Observing the market statistics for the AHTS segment in Table 4 and Figure 6, the same development as for the PSV market can be seen. Figure 7 shows the distribution of employed and unemployed AHTS vessels, and indicates that the employed vessels are more evenly distributed between the spot and term market, than for the PSV segment. The even distribution is caused by the highly active and transparent AHTS spot market in the North Sea, accounting for 95 % of total fixtures. Additionally, the AHTS spot market is significantly more volatile than the PSV spot market, causing more frequent spikes in the utilization rate of AHTS vessels. Furthermore, the AHTS fleet seems to suffer significantly from the recent weak market, as the utilization rate has dropped from its peak of 84 % in 2008, to 59 % in June 2016. Unlike the findings from the PSV market, it seems that the smallest vessel class has a greater ability to maintain a somewhat high activity, compared to the larger vessels. However, the medium sized vessels seem to suffer the most from the market turmoil.

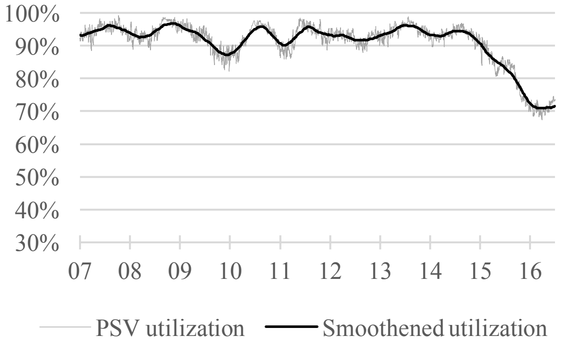

Figure 4: PSV utilization 2007-2016

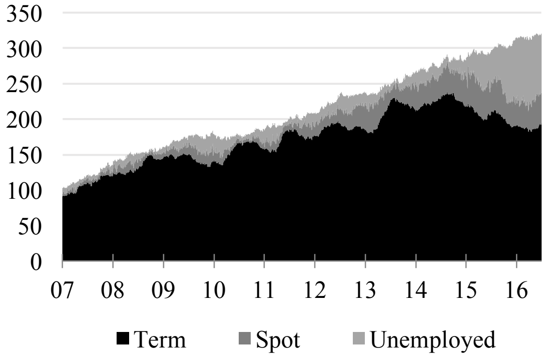

Figure 5: Number of employed and unemployed PSVs 2007-2016

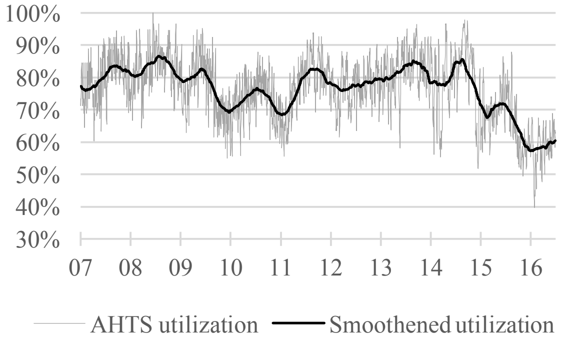

Figure 6: AHTS utilization 2007-2016

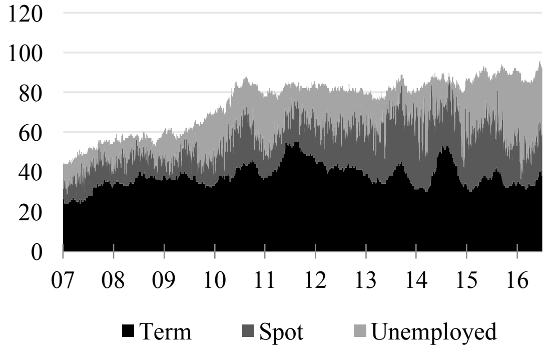

Figure 7: Number of employed and unemployed AHTS vessels 2007-2016

Table 2: Descriptive statistics of age, size and specifications of the North Sea PSV fleet

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PSV specs:										
No of vessels	120	152	175	181	202	231	151	276	294	313
Avg. age of fleet (years)	6	6.3	6.6	7.1	7.4	7.1	6.8	7	7.6	8.6
Max age of fleet	28	29	30	31	32	33	34	35	36	37
Min age of fleet	0	0	0	0	0	0	0	0	0	0
Avg. deck size (m^2)	813	819	815	829	836	851	865	876	873	869
Max deck size	1 270	1 270	1 270	1 270	1 270	1 270	1 220	1 220	1 220	1 220
Min deck size	500	500	500	500	500	500	500	500	500	500
Avg. bulk capacity (m^3)	1 827	1 926	1 964	2 046	2 096	2 290	2 457	2 510	2 515	2 467
Max bulk capacity	3 545	3 545	4 946	4 946	4 946	4 946	4 946	4 946	4 946	4 946
Min bulk capacity	892	892	892	892	892	892	892	892	892	892
Avg. daily fexp (USD)	6 150	8 990	5 222	7 097	10 128	10 105	9 521	8 457	4 925	3 523
Max daily fexp	27 407	41 064	21 708	27 963	37 262	36 827	36 004	32 308	21 030	15 846
Min daily fexp	1 547	1 466	1 280	2 055	2 003	1 831	1 801	1 597	687	585
Avg. consumption (tonnes)	10.60	10.60	10.59	10.61	10.77	10.60	10.49	10.37	10.32	10.39
Max consumption	36.24	36.24	36.24	36.24	36.24	36.24	36.24	36.24	36.24	36.24
Min consumption	3.50	3.50	3.50	3.50	2.14	2.14	2.14	2.14	2.14	2.14
Proportion DP1 (%)	18.97	16.61	17.39	14.22	12.01	9.48	7.60	6.98	6.69	7.34
Proportion DP2	81.03	83.39	82.61	85.78	87.99	90.52	92.40	93.02	93.31	92.66
Proportion ROV	9.50	7.63	8.19	8.45	7.98	6.94	6.00	5.84	5.41	5.38
Proportion IC	6.44	8.28	9.60	10.52	12.41	18.58	25.84	25.85	26.88	26.22
Proportion FIFI	24.42	27.95	30.12	31.72	34.14	35.74	37.44	39.14	39.88	39.68
Proportion NWE	83.88	80.53	80.14	79.33	77.31	77.07	75.26	71.53	71.50	71.17
PSV 500-900 m^2 specs:										
Total active fleet	67	82	98	93	101	108	111	109	136	148
Avg. age of fleet (years)	6.12	6.34	6.54	7.3	7.82	8.03	7.65	7.92	8.11	8.97
Avg. deck size (m^2)	684	689	683	686	692	698	706	717	728	727
Avg. bulk capacity (m^3)	1 693	1 741	1 758	1 789	1 806	1 887	2 015	2 067	2 130	2 118
Avg. daily fexp (USD)	5 855	8 567	5 001	6 748	9 692	9 834	9 281	8 228	4 779	3 508
Avg. consumption (tonnes)	10.10	10.12	10.16	10.10	10.31	10.31	10.23	10.09	10.02	10.06
Proportion DP1 (%)	33.59	29.91	30.56	26.70	23.06	19.44	16.73	15.78	14.13	15.17
Proportion DP2	66.41	70.01	69.44	73.30	76.94	80.56	83.27	84.22	85.87	84.83
Proportion ROV	12.47	10.19	11.16	11.62	11.23	10.44	9.79	9.88	8.86	8.34
Proportion IC	3.12	1.89	1.08	0.20	0.30	2.87	6.27	8.01	12.66	12.38
Proportion FIFI	34.16	37.33	40.19	41.80	45.71	49.34	51.64	53.66	55.45	55.65
Proportion NWE	84.72	79.96	79.46	78.16	74.02	72.20	69.69	67.49	66.95	65.10
PSV 900+ m^2 specs:										
Total active fleet	53	70	79	88	101	123	140	157	158	165
Avg. age of fleet (years)	5.7	6.3	6.8	6.8	6.9	6.2	6.1	6.4	7.2	8.3
Avg. deck size (m^2)	981	982	988	992	993	996	997	1 001	1 002	1 000
Avg. bulk capacity (m^3)	2 010	2 161	2 231	2 334	2 406	2 656	2 816	2 872	2 866	2 807
Avg. daily fexp (USD)	6 517	9 499	5 504	7 490	10 596	10 351	9 711	8 632	5 050	3 725
Avg. consumption (tonnes)	11.22	11.18	11.14	11.19	11.26	10.86	10.70	10.58	10.57	10.67
Proportion DP1 (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion DP2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Proportion ROV	5.64	4.44	4.28	4.83	4.44	3.61	2.84	2.63	2.30	2.59
Proportion IC	10.76	16.26	20.83	22.32	25.90	33.53	41.65	40.13	40.08	39.58
Proportion FIFI	11.79	16.23	16.84	20.23	21.57	22.80	25.63	27.80	26.39	25.20
Proportion NWE	82.79	81.23	81.05	80.67	80.88	81.70	79.90	74.71	75.54	76.78

Table 3: Descriptive statistics of age, size and specifications of the North Sea AHTS fleet

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Total AHTS fleet:										
No of vessels	50	57	63	79	82	82	80	86	92	91
Avg. age (years)	8.5	8.5	8.0	7.0	7.5	8.3	9.6	10.4	11.2	12.1
Max age	23.0	24.0	25.0	26.0	27.0	28.0	29.0	30.0	31.0	32.0
Min age	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. bhp	17 153	17 152	16 990	18 550	19 169	18 879	19 479	19 879	20 289	20 059
Max bhp	27 920	27 920	28 000	36 000	36 000	36 000	36 000	36 000	36 000	36 000
Min bhp	6 436	6 436	6 436	6 436	6 436	6 436	6 436	6 436	6 436	6 436
Avg. daily fexp (USD)	11 127	16 361	9 978	15 373	21 532	21 859	20 524	18 608	11 593	8 219
Max daily fexp	37 913	56 656	44 925	57 870	77 115	76 215	74 513	66 863	45 223	32 794
Min daily fexp	3 314	3 559	3 108	4 992	6 895	6 909	6 288	4 187	2 719	2 315
Avg. consumption (tonnes)	19.22	19.31	20.09	22.93	22.93	22.92	22.62	22.79	24.21	23.62
Max consumption	50.00	50.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00	75.00
Min consumption	7.50	7.50	8.50	8.50	8.50	7.50	7.50	7.50	7.50	7.50
Proportion DP1 (%)	22.26	22.83	21.58	16.02	17.33	17.52	16.80	15.38	15.74	16.08
Proportion DP2	77.74	77.17	78.42	83.98	82.67	82.48	83.20	84.62	84.26	83.92
Proportion ROV	16.80	17.53	19.20	30.68	31.45	27.70	27.96	26.04	30.55	29.62
Proportion IC	54.39	58.49	54.78	55.02	53.86	55.40	58.13	60.07	64.67	63.54
Proportion FIFI	51.05	51.35	55.13	50.80	49.34	49.64	48.40	54.12	53.10	51.44
Proportion Helideck	4.05	3.57	3.22	2.56	2.50	2.47	2.54	2.42	2.29	2.11
Proportion Moonpool	11.68	11.34	8.16	7.14	7.81	7.73	7.61	7.27	7.83	7.86
Proportion NWE	81.39	77.08	81.01	81.53	79.02	74.84	75.86	73.42	74.68	75.84
AHTS 10,000-15,999 bhp:										
No of vessels	21	21	26	27	27	28	25	25	25	26
Avg. age (years)	11.7	12.5	11.0	11.2	12.5	13.9	15.9	17.5	19.0	19.4
Avg. bhp	12 985	12 433	12 879	12 888	12 709	12 397	12 423	12 666	12 198	12 163
Avg. daily fexp (USD)	11 094	15 559	8 935	12 119	17 941	17 883	16 766	15 262	8 936	6 387
Avg. consumption (tonnes)	19.29	18.44	18.11	18.12	19.11	18.77	18.46	18.58	18.76	18.23
Proportion DP1 (%)	43.45	44.69	39.13	35.07	40.42	42.77	43.42	41.17	45.89	44.98
Proportion DP2	56.55	55.31	60.87	64.93	59.58	57.23	56.58	58.83	54.11	55.02
Proportion ROV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion IC	23.05	30.37	22.01	17.81	23.04	26.63	30.82	31.75	36.27	33.66
Proportion FIFI	64.90	62.76	68.27	73.78	76.82	69.42	67.39	70.59	65.99	64.80
Proportion Helideck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion Moonpool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion NWE	64.44	56.69	66.60	63.02	59.58	57.42	56.43	56.95	52.30	52.54
AHTS 16,000-19,999 bhp:										
No of vessels	16	20	21	23	24	26	24	25	24	24
Avg. age (years)	6.3	5.8	6.0	6.6	7.0	6.5	8.5	9.8	10.7	12.3
Avg. bhp	17 592	17 416	17 331	17 361	17 509	17 484	17 665	17 656	17 608	17 664
Avg. daily fexp (USD)	10 354	15 745	9 752	13 086	18 372	18 830	17 197	15 639	9 173	6 512
Avg. consumption (tonnes)	17.76	18.61	19.91	19.52	19.57	19.74	18.96	19.06	19.18	18.70
Proportion DP1 (%)	8.23	14.38	13.24	11.78	10.53	5.47	7.47	9.13	9.34	9.67
Proportion DP2	91.77	85.62	86.76	88.22	89.47	94.53	92.53	90.87	90.66	90.33
Proportion ROV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion IC	84.87	77.76	81.66	81.15	82.84	83.08	84.05	88.16	90.66	90.33
Proportion FIFI	38.54	45.83	52.10	52.75	52.69	59.55	65.79	72.44	74.57	69.32
Proportion Helideck	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion Moonpool	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion NWE	91.79	83.52	86.76	81.43	75.10	67.54	69.78	67.39	64.95	69.35
AHTS 20,000+ bhp:										
No of vessels	13	16	16	29	31	28	31	36	43	41
Avg. age (years)	5.2	5.5	4.9	3.2	3.2	3.8	4.8	5.5	6.6	7.2
Avg. bhp	23 828	23 816	23 901	24 993	26 382	27 139	26 851	26 615	26 615	26 639
Avg. daily fexp (USD)	11 947	18 228	12 089	20 179	27 028	28 749	26 055	22 920	14 439	10 403
Avg. consumption (tonnes)	20.54	21.38	23.82	30.04	28.77	30.12	28.73	28.22	30.09	29.98
Proportion DP1 (%)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Proportion DP2	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Proportion ROV	62.07	62.87	75.37	82.24	82.08	81.22	71.28	61.39	64.22	65.08
Proportion IC	77.72	78.54	82.09	74.05	63.79	63.69	64.26	63.96	69.95	69.71
Proportion FIFI	39.81	40.66	35.27	26.63	21.13	19.69	20.06	30.64	34.79	33.09
Proportion Helideck	14.97	12.79	12.65	6.86	6.52	7.25	6.45	5.72	4.81	4.65
Proportion Moonpool	43.17	40.66	32.01	19.15	20.38	22.65	19.40	17.15	16.46	17.27
Proportion NWE	100.00	100.00	100.00	100.00	100.00	100.00	96.89	89.40	93.30	94.95

Table 4: Descriptive statistics of the North Sea OSV market

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Bunker price:										
Avg. bunker price (USD)	572	851	491	668	940	954	908	816	479	349
SD bunker price	95	222	80	50	51	48	37	98	74	60
PSV fleet:										
Avg. total utilization (%)	95.20	94.41	91.00	92.53	92.80	92.63	95.57	94.26	81.62	70.69
Avg. term utilization	94.97	94.02	90.13	92.06	92.29	91.85	94.95	93.88	79.19	66.36
Avg. spot utilization	50.16	54.11	49.33	40.84	49.02	55.74	72.32	70.14	46.56	30.59
SD total utilization	1.92	2.73	3.99	3.80	3.51	1.61	1.92	1.65	5.74	1.68
SD term utilization	2.00	2.93	4.45	4.18	3.75	1.74	2.28	1.84	6.24	1.29
SD spot utilization	15.02	12.26	11.46	10.26	13.57	9.96	7.57	7.79	11.34	4.27
PSV 500-900 m^2*:*										
Avg. total utilization (%)	94.45	94.92	89.24	90.79	90.64	90.94	93.69	92.77	74.12	61.59
Avg. term utilization	94.19	94.55	87.92	90.10	89.86	90.03	92.67	91.41	69.96	56.78
Avg. spot utilization	46.04	60.29	50.41	42.72	45.58	50.50	68.95	68.81	36.78	22.50
SD total utilization	2.77	3.08	4.60	4.84	5.56	1.94	2.94	2.42	6.86	1.70
SD term utilization	2.88	3.29	5.18	5.31	6.09	1.98	3.43	2.86	7.03	1.20
SD spot utilization	20.59	18.03	12.21	13.83	15.38	10.76	10.35	8.68	11.05	3.31
PSV 900+ m^2*:*										
Avg. total utilization (%)	96.17	93.79	93.32	94.56	95.18	94.26	97.15	95.45	89.30	79.12
Avg. term utilization	96.00	93.42	92.88	94.31	94.89	93.61	96.78	94.88	87.48	75.60
Avg. spot utilization	56.52	45.84	46.23	35.48	54.21	60.86	77.38	71.42	60.00	41.05
SD total utilization	2.43	3.10	4.31	3.17	2.57	2.60	1.91	1.60	4.88	2.13
SD term utilization	2.50	3.26	4.64	3.41	2.72	2.93	2.23	1.76	5.52	1.93
SD spot utilization	26.39	19.84	19.94	20.96	19.79	14.01	10.82	9.96	13.41	6.42
AHTS fleet:										
Avg. total utilization (%)	79.94	83.66	76.13	73.05	77.20	76.93	82.19	79.31	67.88	59.08
Avg. term utilization	74.22	79.75	71.07	65.07	71.79	69.33	72.42	69.98	54.64	48.46
Avg. spot utilization	53.98	55.98	44.59	46.79	48.14	52.63	67.60	62.40	48.58	33.92
SD total utilization	6.82	6.21	8.69	6.48	8.44	5.74	6.86	11.08	8.03	6.15
SD term utilization	7.42	6.58	9.36	5.75	9.23	5.26	7.83	13.11	7.57	3.63
SD spot utilization	14.24	16.28	16.78	12.73	14.70	12.24	12.48	17.55	12.15	10.04
AHTS 10,000-15,999 bhp:										
Avg. total utilization (%)	85.32	90.01	81.61	83.23	86.19	80.95	83.44	84.55	72.06	71.11
Avg. term utilization	82.47	88.72	79.49	81.52	85.07	78.49	79.59	81.14	68.91	69.97
Avg. spot utilization	55.66	58.62	41.49	38.18	40.52	39.95	54.73	57.18	26.44	12.71
SD total utilization	7.31	5.83	9.34	7.08	6.76	6.25	6.15	8.01	4.56	4.99
SD term utilization	7.93	6.08	9.76	7.09	6.78	5.97	6.24	8.49	4.59	4.54
SD spot utilization	19.80	24.37	22.34	20.68	25.94	18.20	17.89	20.32	10.67	10.10
AHTS 16,000-19,999 bhp:										
Avg. total utilization (%)	75.24	76.71	73.49	76.73	76.43	73.34	80.66	81.34	67.02	48.84
Avg. term utilization	65.62	70.57	67.29	72.24	72.66	65.57	71.16	73.15	54.80	40.26
Avg. spot utilization	55.23	50.12	44.69	42.40	39.52	48.70	66.52	65.71	48.51	22.61
SD total utilization	11.20	10.07	9.82	8.00	8.11	10.72	12.12	14.22	14.48	8.67
SD term utilization	12.05	10.02	9.27	7.71	7.81	10.04	13.98	17.95	12.73	4.16
SD spot utilization	19.89	20.68	19.74	19.73	19.97	20.25	21.01	23.91	21.94	13.12
AHTS 20,000+ bhp:										
Avg. total utilization (%)	75.59	81.92	70.18	60.62	69.21	75.85	81.94	74.61	65.57	56.46
Avg. term utilization	68.86	76.23	60.52	33.55	54.67	61.20	65.15	57.65	41.58	33.13
Avg. spot utilization	51.00	61.26	48.41	51.14	54.21	62.74	74.12	63.17	55.21	45.07
SD total utilization	12.26	11.25	15.08	12.17	15.24	10.82	10.79	15.24	10.58	10.89
SD term utilization	12.65	12.75	17.03	11.35	19.91	11.90	15.80	18.04	11.17	5.96
SD spot utilization	23.84	22.20	24.69	14.83	17.18	16.60	15.18	19.62	13.03	13.51

5. Results and discussion

Initially we specify and estimate an annual logit model for each vessel segment, for both the spot and term market. Furthermore, we pool the ten-year data and estimate a panel logit model for both vessel segments. To capture the variations within each vessel class, we extend the analysis by specifying a corresponding model for both PSV classes and the three AHTS classes. In addition, to investigate whether the determinants for obtaining a contract have changed recently, we specify a similar panel logit model pooling the years 2015 and 2016. Finally, the estimated parameters are used to calculate and present a vessel's probability of obtaining contracts.

5.1 PSV: Annual logit model

Estimation results for the annual logit model of Eq. 2 for the PSV term market are reported in Table 5, and indicate that the younger and larger PSVs have been more likely to obtain a term contract in the North Sea market throughout the ten-year period. Similarly, the estimation results for the PSV spot market are reported in Table 6, suggesting that younger and larger PSVs have been more likely to obtain spot contracts as well. The significant number of newbuildings entering the market in recent years further cause the trend of preferring younger vessels to increase. However, it seems that the preference for young and large vessels have been stronger in the spot market, especially in recent years.

Furthermore, the specification preferences seem to be similar in both markets, as the medium complexity vessels have been rewarded both in the spot and term market. This is indicated by the DP2, ice classification and ROV coefficients, and in line with the PSV newbuilding activity, as numerous new vessels have FIFI capabilities and ice classification, while fewer have ROV. However, PSVs with FIFI capability seem unable to compete with the standby vessels operating at most fields in the North Sea. DP2, the most highlighted determinant by market participants, seems to be an important feature both historically and recently. This is expected, as 92 % of the total PSV fleet have a DP2 system. In addition, the NWE built vessels remain the most preferred for both contract types, even though we have seen foreign vessel supplementation in recent years.

The results indicate no consistent preference for vessels with fuel expenditure below the average in either market. However, in the weak market years of 2008 and 2009, vessels with below average fuel expenditure were preferred for both term and spot contracts. Furthermore, the high bunker price levels of 2011 and 2012 may have caused vessels with low fuel cost to be preferred for term contracts. Finally, large bulk capacity seems to be more attractive in the spot market in recent years, compared to the term market.

The value of the McFadden R^2 tends to increase over the years for the spot model, while it is consistently low in the term model. An explanation for this may be that the model is better at distinguishing between vessel specifications in a market with low utilization. Hence, the model struggles to define the most suitable vessel for the term market, causing the estimates of the different variables to appear random. Another explanation for the low values may be that the determinants for obtaining a contract actually have been more random in the term market.

Table 5: Estimation results of the logit model for North Sea PSV Term Fixtures

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
constant	1.579***	0.312***	0.316***	0.188	-0.432***	0.900***	2.545***	4.422***	0.371***	-0.646***
	(10.292)	(2.576)	(2.949)	(1.633)	(-3.867)	(8.555)	(20.355)	(38.248)	(4.897)	(-7.296)
age	-0.002	0.060***	0.103***	0.028***	-0.035***	-0.052***	-0.048***	-0.067***	-0.040***	-0.046***
	(-0.430)	(14.492)	(31.153)	(8.357)	(-11.414)	(-16.790)	(-13.572)	(-23.193)	(-21.707)	(-20.151)
deck	1.425***	-0.436**	-0.090	3.017***	4.140***	2.338***	1.211***	-1.805***	1.575***	2.139***
	(7.740)	(-2.262)	(-0.658)	(18.581)	(26.763)	(17.424)	(6.917)	(-11.781)	(16.836)	(18.474)
bulkcapacity	-0.289***	1.124***	0.851***	-0.085**	-0.353***	-0.350***	-0.343***	-0.164***	-0.214***	-0.097***
	(-5.980)	(22.362)	(18.938)	(-2.503)	(-12.135)	(-13.947)	(-11.393)	(-6.466)	(-13.796)	(-4.955)
fexp	-0.007	-0.066***	-0.201***	-0.011*	-0.053***	-0.018***	0.059***	0.054***	0.122***	0.064***
	(-0.710)	(-15.767)	(-32.169)	(-1.748)	(-13.486)	(-5.015)	(9.146)	(9.657)	(22.239)	(8.547)
dp2	0.154**	0.740***	0.909***	0.167***	0.349***	0.516***	0.638***	0.966***	0.483***	0.184***
	(2.133)	(12.026)	(21.330)	(3.198)	(7.415)	(11.068)	(9.623)	(17.340)	(12.449)	(3.812)
ic	0.993***	-0.724***	0.437***	-0.038	-0.674***	-0.758***	0.486***	0.631***	0.166***	-0.228***
	(6.352)	(-8.315)	(5.716)	(-0.509)	(-10.909)	(-16.448)	(8.457)	(12.447)	(5.982)	(-6.627)
rov	-0.052	-0.156*	-0.574***	0.240***	0.233***	0.470***	0.002	-0.222***	0.186***	-0.057
	(-0.681)	(-1.733)	(-11.037)	(3.581)	(3.792)	(8.168)	(0.033)	(-3.795)	(5.159)	(-1.304)
fifi	-0.436***	0.806***	-0.127***	0.029	0.486***	0.054	-0.562***	-0.712***	-0.305***	-0.096***
	(-7.475)	(14.479)	(-3.628)	(0.770)	(12.341)	(1.618)	(-13.314)	(-19.905)	(-14.799)	(-3.729)
nwe	0.737***	-0.381***	-1.146***	-0.298***	0.129***	0.311***	0.328***	0.353***	0.013	-0.028
	(11.890)	(-5.187)	(-19.631)	(-6.156)	(3.139)	(8.355)	(7.760)	(9.800)	(0.569)	(-0.963)
No observ.	31772	39369	43911	46544	51274	57358	62185	65412	67654	36593
McFadden R2	0.034	0.060	0.084	0.028	0.046	0.031	0.040	0.059	0.035	0.030
Log-likelihood	-6743	-8190	-13311	-11730	-13719	-17217	-11064	-13489	-34948	-23352
SBIC	13590	16485	26729	23568	27547	34543	22239	27090	70008	46808
LR statistic	487.290	1319.820	2182.605	743.142	1413.662	1117.476	1006.660	1765.008	2758.083	1342.619
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

Table 6: Estimation results of the logit model for North Sea PSV Spot Fixtures

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
constant	-1.299***	-1.243***	-0.252	-0.874***	-1.172***	-1.263***	0.091	0.505***	-3.226***	-4.950***
	(-3.959)	(-4.789)	(-1.314)	(-4.381)	(-6.628)	(-8.796)	(0.519)	(2.695)	(-29.794)	(-25.676)
age	0.017***	0.020***	-0.007	-0.028***	0.016***	-0.050***	-0.068***	-0.032***	-0.053***	-0.156***
	(2.625)	(3.022)	(-1.437)	(-3.925)	(3.310)	(-13.656)	(-14.885)	(-8.750)	(-19.823)	(-24.571)
deck	1.033***	0.013	0.315	0.421	0.424*	1.974***	0.433*	-2.153***	2.129***	3.705***
	(3.096)	(0.043)	(1.320)	(1.578)	(1.856)	(10.028)	(1.785)	(-10.784)	(17.202)	(21.191)
bulkcapacity	-0.177	0.441***	0.144**	-0.173***	0.275***	-0.031	-0.107**	0.216***	0.225***	0.312***
	(-1.283)	(5.070)	(2.452)	(-2.629)	(4.628)	(-0.815)	(-2.255)	(5.652)	(10.168)	(9.762)
fexp	-0.002	-0.020**	-0.093***	0.080***	-0.003	0.022***	0.102***	0.083***	0.166***	0.303***
	(-0.076)	(-2.525)	(-8.602)	(5.140)	(-0.477)	(4.236)	(12.636)	(10.708)	(21.273)	(20.624)
dp2	0.071	0.162**	-0.298***	0.494***	0.152*	-0.225***	0.840***	2.160***	0.691***	0.330**
	(0.647)	(2.092)	(-5.218)	(6.001)	(1.960)	(-3.115)	(10.714)	(23.897)	(10.601)	(2.542)
ic	0.562***	-0.279**	-0.135	0.211*	0.663***	-0.417***	-0.144*	0.244***	-0.026	0.119**
	(2.577)	(-2.345)	(-1.236)	(1.726)	(7.948)	(-6.960)	(-1.953)	(4.089)	(-0.767)	(2.511)
rov	-0.029	-0.485***	-0.045	0.233**	-0.055	0.223**	0.109	-0.215***	-0.038	0.000
	(-0.213)	(-4.224)	(-0.637)	(2.574)	(-0.652)	(2.427)	(1.192)	(-2.697)	(-0.618)	(.)
fifi	-0.361***	0.570***	0.047	-0.317***	-0.223***	0.123**	-0.361***	-0.354***	0.281***	0.462***
	(-3.772)	(6.540)	(0.875)	(-4.361)	(-3.203)	(2.395)	(-6.434)	(-6.129)	(9.286)	(9.010)
nwe	0.870***	0.412***	-0.022	0.506***	-0.129	0.662***	1.168***	0.499***	0.446***	0.894***
	(7.235)	(4.342)	(-0.296)	(5.044)	(-1.459)	(10.900)	(17.066)	(8.881)	(12.460)	(16.435)
No observ.	3634	5404	9395	6011	7984	12342	11817	15849	29401	18821
McFadden R2	0.045	0.023	0.011	0.024	0.025	0.032	0.073	0.081	0.087	0.229
Log-likelihood	-2405	-3618	-6441	-4005	-5389	-8176	-6046	-7989	-18590	-9421
SBIC	4892	7321	12973	8098	10867	16447	12185	16074	37283	18930
LR statistic	200.912	169.203	134.697	178.269	286.823	479.010	918.509	1320.668	2983.509	4060.194
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16
- ROV is omitted in 2016, as it predicts failure perfectly

5.2 PSV: Panel model and estimation results

Table 7 and 8 show the panel logit model of Eq. 4 for PSVs from 2007 to 2016 and for the years 2015 and 2016, respectively. The estimates confirm the consistent preference for younger and larger vessels indicated in the annual logit model. These findings are in line with the hypothesis and market development of demanding larger PSVs to supply the increasing number of installations with the necessary equipment. Furthermore, a larger PSV may serve several installations in one trip, which reduces the transportation cost per unit and is thus favourable for the operators.

In addition, the results support the finding that medium complex vessels built in NWE have been preferred in both markets. Furthermore, the estimation results confirm that a large bulk capacity seems preferred in the spot market, while low fuel expenditure seems to be a less important determinant in both markets.

Observing the variation within the vessel classes, there seems to be significant differences in the determinants. Primarily, the smallest vessels in the small PSV class seem to be preferred in both markets, while the age of the vessel appears to be of less importance in the spot market.

Furthermore, low fuel expenditure and a higher degree of complexity is valued in the term market, indicated by the coefficients for ROV.

For the large vessel class, there seems to be a significant difference in size preference in both markets, comparing historical and recent results. While increasing deck size has been rewarded historically, smaller deck size is preferred in recent years, which seems to further affect the importance of bulk capacity. Thus, there seems to exist an upper size limit for the most suitable PSVs operating in the North Sea recently.

As expected, there is a strong positive relationship between the probability of obtaining contracts and the market condition for all classes in both markets, indicated by the coefficients for market utilization.

Table 7: Estimation results of the logit model for North Sea PSV Fixtures 2007-2016

	PSV 500-900 m^2 term	PSV 500-900 m^2 spot	PSV 900+ m^2 term	PSV 900+ m^2 spot	PSV Total term	PSV Total spot
constant	-5.521***	-9.612***	-6.192***	-5.651***	-7.673***	-8.120***
	(-65.727)	(-72.646)	(-33.097)	(-22.933)	(-131.660)	(-99.405)
age	-0.029***	-0.001	-0.027***	-0.053***	-0.022***	-0.028***
	(-24.268)	(-0.808)	(-16.060)	(-23.971)	(-24.137)	(-24.984)
deck	-1.246***	-1.025***	1.057***	1.101***	1.626***	1.210***
	(-15.801)	(-7.169)	(5.690)	(5.349)	(38.236)	(20.300)
bulkcapacity	-0.394***	0.758***	-0.086***	0.122***	-0.142***	0.260***
	(-21.720)	(31.188)	(-8.429)	(7.917)	(-16.689)	(21.048)
fexp	-0.029***	0.034***	-0.002	0.029***	-0.014***	0.034***
	(-12.552)	(9.720)	(-0.656)	(7.100)	(-8.958)	(13.338)
dp2	0.439***	0.225***			0.475***	0.280***
	(27.671)	(9.415)			(30.519)	(12.920)
ic	-0.320***	0.263***	0.056***	0.159***	0.034**	0.220***
	(-11.316)	(7.267)	(2.890)	(6.290)	(2.212)	(11.118)
rov	0.222***	-0.335***	-0.357***	-0.101**	0.019	-0.151***
	(11.181)	(-12.101)	(-8.563)	(-2.216)	(1.110)	(-6.516)
fifi	0.111***	0.212***	-0.193***	0.050*	-0.140***	0.105***
	(7.873)	(9.831)	(-10.736)	(1.807)	(-13.347)	(6.663)
nwe	0.026	0.272***	0.319***	0.686***	0.015	0.425***
	(1.636)	(10.709)	(16.230)	(21.483)	(1.217)	(22.036)
utilization	9.884***	9.387***	8.898***	5.164***	9.641***	7.115***
	(146.935)	(87.618)	(120.674)	(49.159)	(193.719)	(100.174)
No observ.	245188	67892	256884	52967	502072	120859
McFadden R2	0.140	0.121	0.104	0.076	0.125	0.105
Log-likelihood	-88019	-41226	-64615	-32774	-155165	-74780
SBIC	176174	82575	129355	65657	310475	149690
LR statistic	27706.581	9707.906	18022.835	4831.146	46064.169	15403.259
p-val	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

Table 8: Estimation results of the logit model for North Sea PSV Fixtures 2015-2016

	PSV 500-900 m^2 term	PSV 500-900 m^2 spot	PSV 900+ m^2 term	PSV 900+ m^2 spot	PSV Total term	PSV Total spot
constant	-2.572^{***}	-10.302^{***}	6.572^{***}	0.497	-4.980^{***}	-9.469^{***}
	(-17.779)	(-43.041)	(25.292)	(1.388)	(-48.642)	(-62.693)
age	-0.060^{***}	0.008^{*}	-0.100^{***}	-0.180^{***}	-0.041^{***}	-0.082^{***}
	(-32.065)	(1.849)	(-38.015)	(-47.281)	(-28.358)	(-33.398)
deck	-0.983^{***}	-2.257^{***}	-9.194^{***}	-5.431^{***}	1.860^{***}	2.760^{***}
	(-6.792)	(-7.560)	(-41.909)	(-18.253)	(25.556)	(27.339)
bulkcapacity	-0.671^{***}	1.266^{***}	-0.162^{***}	-0.007	-0.185^{***}	0.225^{***}
	(-23.244)	(25.450)	(-9.789)	(-0.329)	(-14.951)	(12.249)
fexp	-0.066^{***}	0.049^{***}	0.211^{***}	0.279^{***}	0.051^{***}	0.140^{***}
	(-9.822)	(4.747)	(28.928)	(25.929)	(12.325)	(19.854)
dp2	0.341^{***}	0.161^{**}			0.383^{***}	0.467^{***}
	(11.665)	(2.302)			(12.532)	(7.899)
ic	-0.655^{***}	-0.056	0.172^{***}	0.081^{**}	0.025	0.105^{***}
	(-16.944)	(-1.114)	(5.926)	(2.256)	(1.142)	(3.626)
rov	0.403^{***}	-0.845^{***}	-0.512^{***}	-0.994^{***}	0.082^{***}	-0.332^{***}
	(13.629)	(-12.257)	(-6.778)	(-6.919)	(3.035)	(-6.202)
fifi	0.283^{***}	0.981^{***}	0.021	0.505^{***}	-0.225^{***}	0.278^{***}
	(12.028)	(22.331)	(0.702)	(11.610)	(-13.739)	(10.601)
nwe	0.150^{***}	0.192^{***}	0.391^{***}	1.375^{***}	-0.036^{*}	0.564^{***}
	(5.997)	(4.868)	(12.203)	(25.725)	(-1.922)	(18.282)
utilization	6.739^{***}	9.436^{***}	6.513^{***}	6.946^{***}	6.390^{***}	7.429^{***}
	(47.150)	(42.700)	(38.300)	(29.280)	(60.727)	(48.858)
No observ.	49862	27147	54385	22349	104247	49496
McFadden R2	0.068	0.171	0.105	0.186	0.063	0.169
Log-likelihood	-30609	-14139	-23736	-12566	-57584	-27960
SBIC	61338	28391	47580	25233	115296	56038
LR statistic	4180.795	4277.965	5134.213	4002.544	7274.999	8477.186
p-val	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

Finally, the estimated parameters from the panel logit models are used to compute the probability of obtaining contracts, given vessel specifications. The probabilities for the PSV spot and term market are illustrated in Figure 8 and 9. Investigating the slope of the surfaces enables us to distinguish between the importance of age, deck and the market condition. Moreover, the relationship between the most suitable and least suitable vessels[11], according to the model, are represented by the vertical shift of the probability surfaces in panel (a) and (b) for both figures.

Overall, it seems that the probability for the spot market is more sensitive to the different determinants. As stated, the probability of obtaining contracts increases with age and deck size in both markets. However, this effect seems to be slightly smaller in the term market compared

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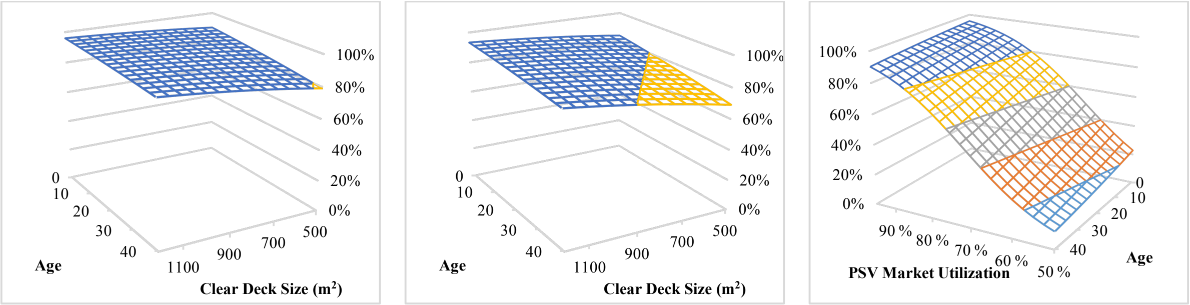
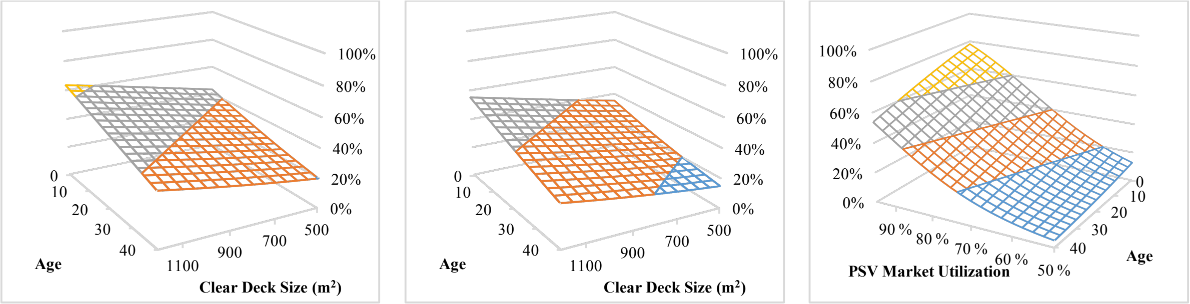
[11] The suitability of a vessel is characterized by the significance and sign of the technical specification coefficients, i.e. the most suitable vessel in the PSV term market (2007-2016) has DP2, IC and built in NWE, while the least suitable vessel has FIFI capabilities.

to the spot market historically, while it seems to have increased for both markets recently. Furthermore, having the most suitable specifications appears to be a significantly more determining factor in the spot market. This is driven by the preference for NWE built vessels with DP2, and reflected by comparing the marginal effect of 29 % and 4% between having the most and least suitable vessel in the historical spot and term market, respectively. As expected, both markets are first and foremost dependent on the market condition. Historically, the spot market has been more sensitive to the market condition, however the term market sensitivity has increased recently.

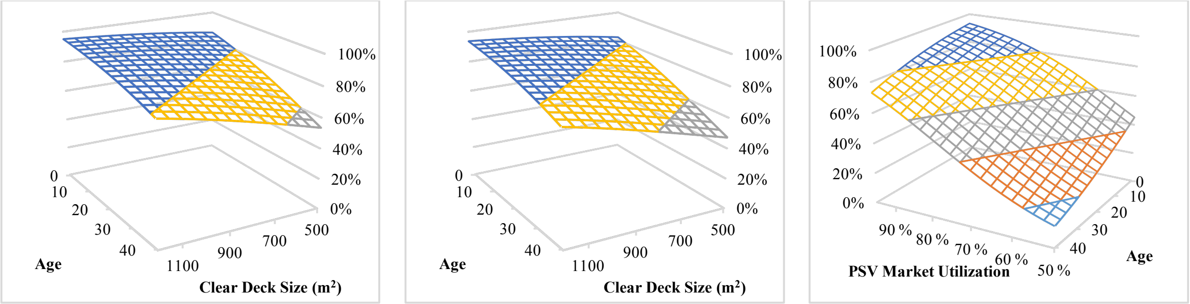


(a) Most suitable vessels term (b) Least suitable vessels term (c) Term sensitivity to market condition

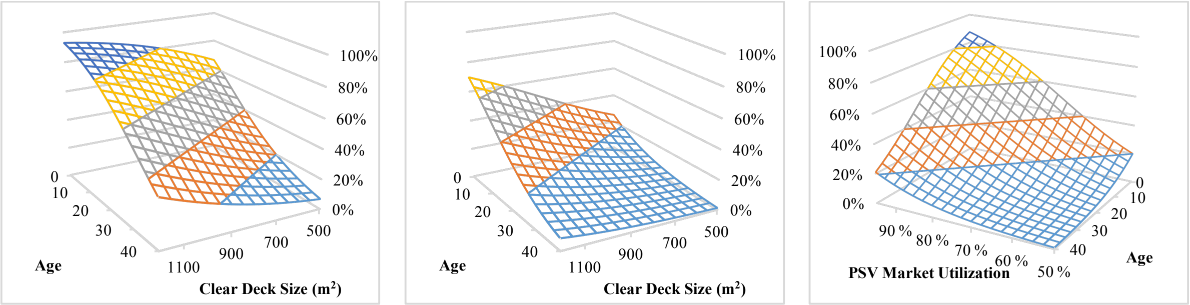


(d) Most suitable vessels spot (e) Least suitable vessels spot (f) Spot sensitivity to market condition

Figure 8: Probability of obtaining a contract in the PSV term and spot market 2007-2016



(a) Most suitable vessels term (b) Least suitable vessels term (c) Term sensitivity to market condition



(d) Most suitable vessels spot (e) Least suitable vessels spot (f) Spot sensitivity to market condition

Figure 9: Probability of obtaining a contract in the PSV term and spot market 2015-2016

5.3 AHTS: Annual logit model

The annual logit model for Eq. 3 for the AHTS term market is reported in Table 9, indicating a preference towards older and less powerful vessels. The trend of preferring older vessels seems to have decreased post 2011. This may be due to the significant number of newbuildings that entered the market from 2011, increasing the competition for contracts. Further, there has been a shift towards preferring less complex vessels, supported by the consistent preference for AHTS vessels with DP1 systems post 2010. In addition, vessels with firefighting capabilities, and special features such as helideck and moonpool, seem to be preferred. The results further indicate that vessels with below average fuel expenditure were preferred for term contracts from 2009 to 2011, when the market was weak and the bunker price was increasing. We find no consistent preference towards build region for vessels in the term market.

Table 9: Estimation results of the logit model for North Sea AHTS Term Fixtures

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
constant	0.429^{***}	1.629^{***}	0.769^{***}	0.350^{***}	0.768^{***}	1.952^{***}	4.386^{***}	4.669^{***}	1.737^{***}	2.751^{***}
	(3.935)	(14.351)	(7.342)	(3.534)	(7.402)	(16.598)	(34.429)	(31.811)	(18.748)	(17.752)
age	0.127^{***}	0.078^{***}	0.120^{***}	0.080^{***}	0.070^{***}	0.037^{***}	-0.052^{***}	-0.035^{***}	0.009^{***}	0.004
	(22.765)	(11.979)	(30.631)	(25.062)	(19.276)	(10.090)	(-17.578)	(-12.586)	(4.296)	(1.334)
bhp	-9.076^{***}	-19.422^{***}	-16.831^{***}	-6.009^{***}	-0.190	-3.240^{***}	-5.458^{***}	-10.731^{***}	-0.725^{**}	-4.150^{***}
	(-14.243)	(-30.771)	(-25.207)	(-12.069)	(-0.462)	(-7.434)	(-11.707)	(-23.932)	(-2.161)	(-8.035)
fexp	-0.014^{**}	0.021^{***}	-0.011^{***}	-0.016^{***}	-0.003^{*}	0.008^{***}	0.023^{***}	-0.002	0.007^{***}	0.085^{***}
	(-2.471)	(5.699)	(-3.280)	(-9.097)	(-1.834)	(4.419)	(9.417)	(-0.837)	(3.432)	(16.524)
dp2	1.325^{***}	0.896^{***}	1.145^{***}	0.614^{***}	-0.854^{***}	-1.530^{***}	-1.959^{***}	-1.902^{***}	-0.562^{***}	-1.202^{***}
	(14.948)	(10.033)	(17.553)	(9.590)	(-10.682)	(-18.911)	(-29.636)	(-25.224)	(-11.856)	(-15.504)
ic	-0.274^{***}	0.619^{***}	1.025^{***}	0.707^{***}	-0.064^{*}	0.256^{***}	-0.666^{***}	0.212^{***}	-0.034	-0.050
	(-5.035)	(9.085)	(21.075)	(18.016)	(-1.756)	(6.634)	(-15.197)	(5.422)	(-1.028)	(-1.022)
rov	1.448^{***}	0.128	0.528^{***}	-0.975^{***}	-0.475^{***}	-0.460^{***}	-0.718^{***}	0.293^{***}	-0.548^{***}	-0.432^{***}
	(17.945)	(1.554)	(8.005)	(-18.772)	(-10.036)	(-8.077)	(-10.903)	(5.326)	(-12.587)	(-6.930)
fifi	0.810^{***}	1.373^{***}	1.630^{***}	0.746^{***}	0.928^{***}	0.525^{***}	0.046	-0.163^{***}	-0.046	0.201^{***}
	(16.689)	(26.412)	(37.334)	(19.552)	(23.874)	(14.055)	(1.017)	(-3.706)	(-1.368)	(4.202)
helideck	2.104^{***}	1.402^{***}	0.758^{***}	-3.133^{***}	0.424^{***}	-0.665^{***}	1.213^{***}	0.745^{***}	0.842^{***}	0.722^{***}
	(13.924)	(6.335)	(5.552)	(-24.595)	(2.880)	(-3.791)	(5.642)	(3.902)	(7.396)	(5.179)
moonpool	-0.994^{***}	1.216^{***}	1.003^{***}	1.995^{***}	0.638^{***}	2.722^{***}	1.989^{***}	1.859^{***}	0.750^{***}	0.704^{***}
	(-8.411)	(10.942)	(11.413)	(20.894)	(7.641)	(25.303)	(14.141)	(13.188)	(11.424)	(7.297)
nwe	-0.332^{***}	0.786^{***}	-0.597^{***}	-0.378^{***}	0.230^{***}	-0.058	0.200^{***}	0.061	-1.308^{***}	-1.516^{***}
	(-4.126)	(10.033)	(-11.375)	(-8.293)	(4.233)	(-1.048)	(3.956)	(1.467)	(-34.689)	(-28.750)
No observ.	14178	16537	18635	22227	23931	22254	18765	20920	22910	12567
McFadden R2	0.126	0.136	0.182	0.184	0.142	0.157	0.137	0.111	0.102	0.170
Log-likelihood	-6995	-7207	-9237	-11685	-12136	-11574	-9482	-11317	-14113	-7231
SBIC	14096	14521	18582	23479	24382	23259	19072	22743	28336	14565
LR statistic	2188.706	1785.139	3061.496	4138.528	3829.689	3019.829	2862.681	1724.206	2854.640	2265.297
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

Similarly, estimation results for the AHTS spot market are reported in Table 10, indicating that younger and more powerful vessels have been more likely to obtain spot contracts. Furthermore, there seems to be a trend towards preferring more powerful AHTS vessels over the years. ROV capable vessels with DP2 have been favourable until 2016, while vessels with ice classification seem to have had a higher probability of obtaining spot contracts recently. In addition, a low fuel expenditure does not seem to have been an important determinant in the ten-year period. Finally, NWE built vessels have been significantly more likely obtain spot contracts over the years.

Table 10: Estimation results of the logit model for North Sea AHTS Spot Fixtures

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
constant	-0.203	-0.567***	-2.429***	-1.894***	-1.217***	-1.699***	-1.697***	-0.991***	-2.086***	-0.705***
	(-1.607)	(-3.572)	(-16.169)	(-16.168)	(-8.236)	(-11.450)	(-8.106)	(-6.587)	(-14.833)	(-3.033)
age	-0.002	0.039***	0.018***	-0.015***	-0.016***	-0.011***	-0.058***	-0.015***	-0.022***	-0.087***
	(-0.195)	(6.213)	(3.482)	(-3.587)	(-2.692)	(-3.251)	(-18.689)	(-4.914)	(-6.282)	(-15.221)
bhp	-2.251***	-6.331***	4.254***	2.053***	1.199**	3.815***	-1.599***	-1.643***	4.110***	6.234***
	(-2.599)	(-7.669)	(4.264)	(3.315)	(2.195)	(7.551)	(-3.040)	(-3.624)	(10.351)	(10.756)
fexp	0.043***	0.048***	0.004	-0.010***	-0.003	0.002	0.006***	0.005***	-0.014***	0.032***
	(7.888)	(12.136)	(1.165)	(-5.991)	(-1.585)	(0.846)	(3.020)	(2.629)	(-5.683)	(5.948)
dp2	0.496***	1.118***	0.283***	0.624***	0.464***	0.093	2.188***	0.795***	1.379***	-0.362**
	(5.189)	(13.050)	(3.227)	(7.797)	(3.984)	(0.835)	(12.249)	(8.524)	(14.713)	(-2.014)
ic	-0.209***	-0.156**	0.140***	0.214***	-0.032	0.286***	0.090**	0.158***	0.526***	0.251***
	(-2.968)	(-2.539)	(2.583)	(5.429)	(-0.832)	(7.764)	(2.346)	(4.356)	(14.737)	(4.469)
rov	0.483***	0.990***	0.066	0.172***	0.203***	0.335***	0.247***	0.428***	0.168***	-0.304***
	(4.501)	(10.693)	(0.681)	(2.659)	(3.260)	(5.136)	(3.959)	(7.308)	(3.642)	(-4.295)
fifi	0.034	0.379***	0.315***	0.295***	0.034	0.470***	0.300***	0.173***	-0.485***	-1.192***
	(0.566)	(5.460)	(5.542)	(6.994)	(0.663)	(9.932)	(6.562)	(4.034)	(-13.745)	(-20.515)
helideck	-1.180***	-0.421*	-2.959***	-1.784***	-1.764***	-1.071***	-2.747***	0.000	-1.766***	0.000
	(-3.983)	(-1.904)	(-6.645)	(-10.240)	(-4.951)	(-3.848)	(-8.192)	(.)	(-7.932)	(.)
moonpool	-0.724***	-0.576***	-0.438***	-0.078	-0.085	-0.092	1.253***	0.016	-0.646***	-0.198*
	(-6.011)	(-5.206)	(-4.045)	(-0.853)	(-1.064)	(-0.764)	(10.080)	(0.188)	(-10.027)	(-1.882)
nwe	0.547***	0.672***	0.899***	0.628***	0.444***	0.594***	0.936***	1.081***	-0.144***	0.227**
	(6.156)	(7.696)	(7.457)	(7.770)	(6.092)	(11.515)	(17.869)	(23.158)	(-2.616)	(2.133)
No observ.	7786	7635	9720	14464	12589	14467	15846	16214	19689	9499
McFadden R2	0.032	0.061	0.032	0.039	0.020	0.045	0.092	0.049	0.088	0.155
Log-likelihood	-5201	-4917	-6444	-9613	-8529	-9556	-9045	-10237	-12438	-5185
SBIC	10501	9932	12989	19331	17161	19218	18196	20570	24985	10462
LR statistic	302.451	571.986	359.295	767.610	329.602	822.656	1497.883	1027.057	2408.071	1970.605
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

5.4 AHTS: Panel model and estimation results

Table 11 and 12 show the panel logit model of Eq. 5 for AHTS vessels from 2007 to 2016 and for the years 2015 and 2016, respectively. The estimates confirm the diversified preferences between the term and spot markets found in the annual logit model.

The results indicate that older and less powerful vessels are preferred in the term market. Furthermore, less complex vessels seem suitable, however special features such as helideck and moonpool are also rewarded, adding some complexity to the preferred term vessel. Contrary to the hypothesis, vessels with FIFI capability seem especially suitable in the term market. This may indicate that charterers characterize AHTS vessels having firefighting capabilities as prioritized supplements to standby vessels, in order to fulfil the imposed requirements in regards of safety. We find no clear preference for vessels built in NWE. The results for the AHTS term market from the 2015-2016 model coincide with the historical results, indicating no significant differences in preferences recently.

Table 11: Estimation results of the panel logit model for North Sea AHTS Fixtures 2007-2016

	AHTS 10,000-15,999 bhp term	AHTS 10,000-15,999 bhp spot	AHTS 16,000-19,999 bhp term	AHTS 16,000-19,999 bhp spot	AHTS 20,000+ bhp term	AHTS 20,000+ bhp spot	AHTS Total term	AHTS Total spot
constant	-0.867***	-9.362***	-4.365***	-9.454***	-6.786***	-7.206***	-2.185***	-6.912***
	(-9.920)	(-53.373)	(-21.442)	(-42.422)	(-53.573)	(-59.595)	(-40.239)	(-98.998)
age	0.067***	-0.051***	0.058***	0.002	-0.035***	-0.007**	0.019***	-0.006***
	(39.183)	(-21.917)	(29.229)	(0.631)	(-12.201)	(-2.540)	(19.022)	(-5.859)
bhp	-19.798***	24.914***	5.967***	11.621***	0.726***	5.739***	-4.674***	3.697***
	(-46.061)	(21.885)	(6.299)	(10.966)	(2.760)	(19.550)	(-36.417)	(22.693)
fexp	-0.032***	0.032***	0.040***	0.009***	-0.001	-0.004***	0.005***	-0.000
	(-25.943)	(15.555)	(11.876)	(3.119)	(-1.354)	(-5.221)	(7.237)	(-0.109)
dp2	-0.523***	-0.306***	0.519***	1.056***			-0.596***	0.593***
	(-20.297)	(-5.734)	(15.119)	(20.959)			(-28.461)	(20.682)
ic	-0.526***	0.791***	0.097***	0.531***	-0.122***	0.196***	0.013	0.154***
	(-23.224)	(19.274)	(3.193)	(14.419)	(-4.467)	(8.124)	(1.082)	(11.946)
rov					-0.483***	0.226***	-0.328***	0.275***
					(-23.189)	(8.841)	(-20.707)	(13.466)
fifi	1.366***	-0.086***	-0.469***	0.378***	1.095***	-0.204***	0.472***	0.147***
	(58.984)	(-2.843)	(-19.448)	(13.464)	(46.319)	(-8.871)	(40.218)	(10.359)
helideck					0.321***	-1.961***	0.113***	-1.780***
					(6.935)	(-23.155)	(2.756)	(-22.547)
moonpool					1.189***	-0.140***	1.190***	-0.258***
					(38.790)	(-4.238)	(42.446)	(-9.180)
nwe	-0.232***	0.461***	-0.951***	0.033	1.481***	1.364***	-0.287***	0.459***
	(-9.180)	(10.224)	(-31.519)	(0.909)	(23.209)	(23.070)	(-18.037)	(23.016)
utilization	4.725***	7.755***	5.310***	7.546***	7.040***	6.117***	5.429***	6.789***
	(47.721)	(48.357)	(51.680)	(59.196)	(71.004)	(69.872)	(98.178)	(106.088)
No observ.	81476	29040	51077	34820	60371	64267	192924	128127
McFadden R2	0.144	0.149	0.059	0.103	0.171	0.098	0.127	0.105
Log-likelihood	-35143	-16907	-30836	-21648	-34496	-39542	-105370	-79347
SBIC	70388	33906	61769	43390	69112	79205	210885	158835
LR statistic	10571.951	3685.085	3614.613	4422.230	10504.987	7426.153	26079.480	15431.367
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

Observing the variation within the vessel classes, there seems to be noteworthy differences in the determinants. The preference towards less powerful vessels for term contracts is driven solely by the smallest vessel class. These vessels are preferred to have low fuel expenditures, and the importance of not being NWE built is evident. Additionally, the smallest vessels are preferred to be less complex, indicated by the negative DP2 coefficient. Conversely, the DP2 coefficient indicates that more complexity is rewarded within the larger classes and the preference for helideck and moonpool observed in the annual model seems to be solely driven by the largest vessel class. Furthermore, vessels built in NWE are preferred within the largest vessel class. Thus, it seems that either a less powerful and less complex vessel, or a more powerful and more complex vessel with helideck or moonpool, is required to obtain term contracts. This may be explained as charterers, for flexibility reasons, tend to contract the largest vessels, which are able to perform complicated operations such as mooring, on long term contracts. Conversely, smaller vessels are utilized for simpler tasks such as maintenance and firefighting.

Table 12: Estimation results of the panel logit model for North Sea AHTS Fixtures 2015-2016

	AHTS 10,000-15,999 bhp term	AHTS 10,000-15,999 bhp spot	AHTS 16,000-19,999 bhp term	AHTS 16,000-19,999 bhp spot	AHTS 20,000+ bhp term	AHTS 20,000+ bhp spot	AHTS Total term	AHTS Total spot
constant	2.348***	-9.156***	1.062*	-10.773***	-4.299***	-7.335***	-0.107	-7.228***
	(11.731)	(-17.660)	(1.800)	(-13.475)	(-14.500)	(-31.150)	(-0.902)	(-39.152)
age	0.097***	-0.086***	0.100***	-0.040***	-0.131***	-0.113***	0.007***	-0.040***
	(28.614)	(-8.661)	(11.029)	(-3.547)	(-16.841)	(-18.920)	(4.104)	(-12.834)
bhp	-17.595***	71.832***	-17.315***	18.238***	2.194***	6.905***	-1.297***	5.632***
	(-18.616)	(12.897)	(-4.969)	(4.327)	(3.089)	(11.785)	(-4.595)	(16.562)
fexp	-0.068***	0.041***	-0.001	0.001	0.013***	-0.027***	0.014***	-0.021***
	(-17.957)	(3.003)	(-0.095)	(0.127)	(4.506)	(-10.714)	(7.231)	(-9.198)
dp2	-0.097*	-0.223	0.276***	1.423***			-0.763***	1.036***
	(-1.772)	(-0.953)	(3.736)	(11.353)			(-18.621)	(11.447)
ic	-0.922***	2.648***	0.992***	0.415***	-0.126*	0.050	-0.034	0.502***
	(-15.585)	(19.375)	(7.294)	(6.225)	(-1.667)	(0.987)	(-1.231)	(15.981)
rov					-0.473***	0.125***	-0.510***	0.071*
					(-10.925)	(2.582)	(-14.396)	(1.808)
fifi	0.118**	-3.292***	-2.083***	-0.602***	1.197***	-0.520***	0.037	-0.665***
	(2.361)	(-22.257)	(-30.541)	(-8.953)	(27.415)	(-12.221)	(1.347)	(-21.662)
helideck					1.619***	-1.411***	0.711***	-2.144***
					(14.194)	(-6.529)	(8.071)	(-10.170)
moonpool					0.993***	-0.467***	0.741***	-0.614***
					(13.044)	(-6.806)	(13.597)	(-10.789)
nwe	-1.785***	-1.949***	-3.535***	-0.067	0.370***	1.799***	-1.373***	-0.012
	(-35.917)	(-11.527)	(-27.565)	(-0.460)	(4.557)	(16.513)	(-44.474)	(-0.233)
utilization	0.170	3.227***	5.401***	12.533***	5.326***	7.297***	3.193***	7.850***
	(0.683)	(6.460)	(16.214)	(30.763)	(21.448)	(33.951)	(22.269)	(46.542)
No observ.	13410	5242	8423	6624	13644	16980	35477	29341
McFadden R2	0.198	0.236	0.196	0.161	0.161	0.137	0.130	0.158
Log-likelihood	-6599	-2129	-4694	-3782	-7737	-10136	-21319	-16942
SBIC	13284	4335	9470	7626	15578	20378	42764	34008
LR statistic	2845.760	2013.809	2106.708	1042.751	2499.282	2609.072	5241.449	4886.874
p-val	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- ***, ** and * indicate significance at the 1%, 5% and 10%, respectively
- Robust standard errors are estimated using Huber-White quasi-maximum likelihood method.
- SBIC is the Schwarz (1978) Bayesian model selection criteria.
- LR statistic tests the joint significance of all the variables in the model.
- McFadden R^2 is measured as the parentage improvement of the log-likelihood of the estimated model compared with the benchmark model with no variables.
- 2016 data is from 01/01/16 to 06/30/16

On the contrary, younger and more powerful vessels are valued in the spot market. These vessels are especially suitable if they are highly complex, reflected by the coefficients for DP2, ice classification and ROV. In recent markets, low fuel expenditure also seems to be more important, while helideck or moonpool is not preferred for spot contracts. The historical strong preference for NWE built vessels, seems not to exist in recent years.

Observing the variation within the vessel classes, it seems that the smallest vessels are preferred to be less complex in the spot market, as for the term market. High complexity is significantly more important in the largest vessel class, reflected by the coefficients for DP2 and ROV. Vessels with ice classification are preferred for all classes historically, and due to new potential oil and gas fields in the ice prone Barents Sea, one may assume that the positive effect of having ice classification will endure going forward. Furthermore, low fuel expenditure seems to be a determining factor for the largest vessels, which is expected as the fuel cost is a significantly larger cost element for the most powerful vessels.

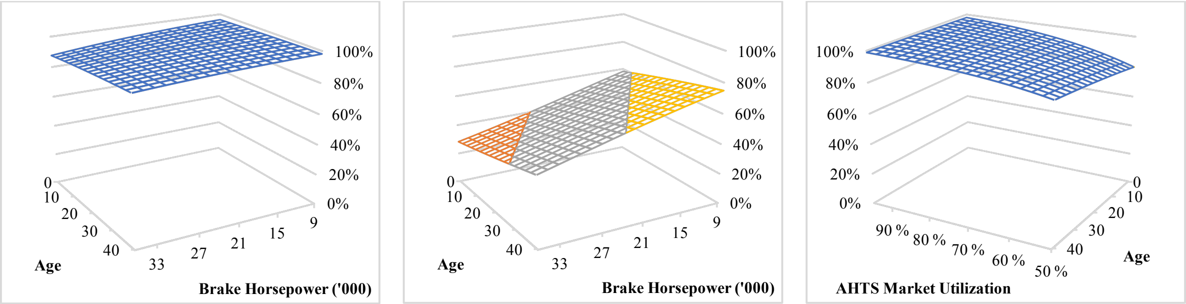
A possible explanation for the coinciding results for the term and spot market may be that some of the work done by AHTS vessels on term contracts is less demanding in terms of vessel power. Furthermore, having a vessel on a term contract enables the charterer to split operations into smaller tasks, so that less powerful and cheaper vessels can be utilized. On the contrary, work induced by a spot contract, such as rig moves, requires more powerful vessels. In addition, increased pre-lay activity in the North Sea makes powerful AHTS vessels more demanded.

Finally, the estimated parameters from the panel logit models are used to compute the probability estimates of obtaining contracts, given vessel specifications. The probabilities for the AHTS term and spot market, both historically and recently, are illustrated in Figure 10 and 11.

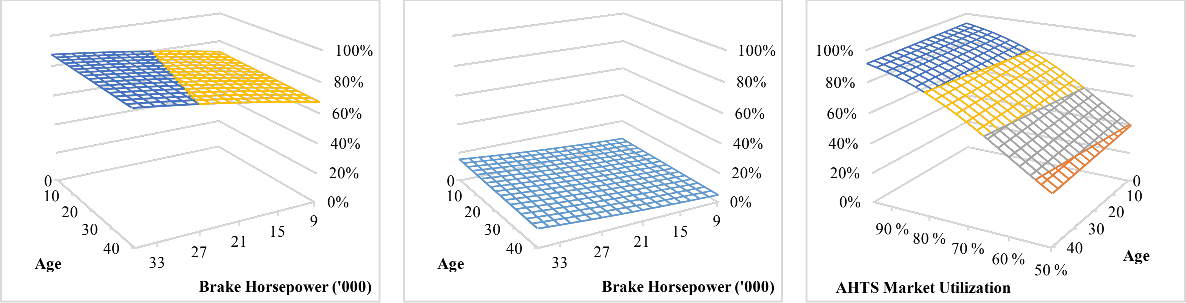
Overall, having the most suitable vessels seems to be the deciding factor for obtaining contracts in the AHTS segment. The marginal effect between having the most and least suitable vessels in the historical term market is 56%, thus having the right set of technical specifications seems to be vital for obtaining term contracts. This is mostly driven by the different preferences in dynamic positioning systems and helideck or moonpool capabilities, and seems to have increased in recent years. Furthermore, the preference for older and smaller vessels seems not to be determining for the most suitable vessels. This is evident as the probability rises with age, while it falls slightly with brake horsepower. These results are as expected, as Table 11 unveiled a strong preference for both smaller and larger vessels in the term market. Finally, the probability estimations for 2015 and 2016 show that the relationship between age, size and the probability of obtaining a term contract has been stable compared to historical results.

For the spot market, having the right set of technical specifications seems to be even more crucial compared to the term market, reflected by the marginal effect of 91 % between having the most and least suitable spot vessel. Thus, it seems that the strong preference for more complex vessels is the most determining factor for obtaining spot contracts. This effect is mostly driven by the largest vessel class. As for the term market, the age and size of the vessel is of less importance historically. However, these factors are more vital in recent years, as the preference for younger and larger vessels has increased.

As for the PSV segment, the AHTS spot market is more sensitive to the market condition than the term market. More noticeably, it seems that the sensitivity to the market condition has decreased for the term contracts, while it has increased for the spot contracts. This indicates that the demand for term vessels has remained somewhat stable during the recent market turmoil.

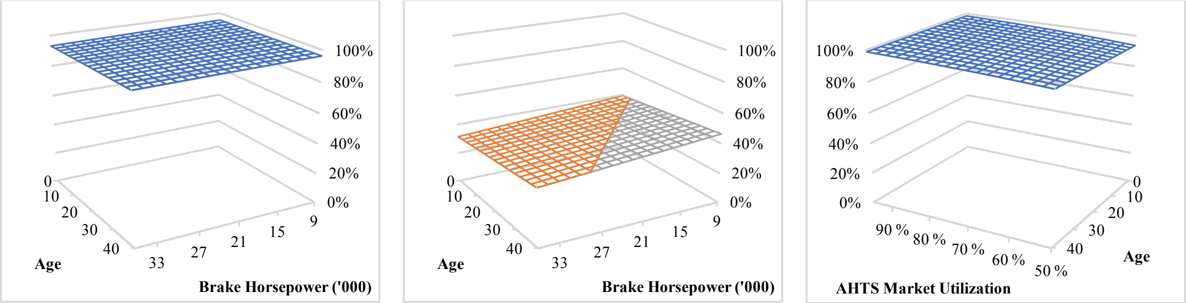


(a) Most suitable vessels term (b) Least suitable vessels term (c) Term sensitivity to market condition

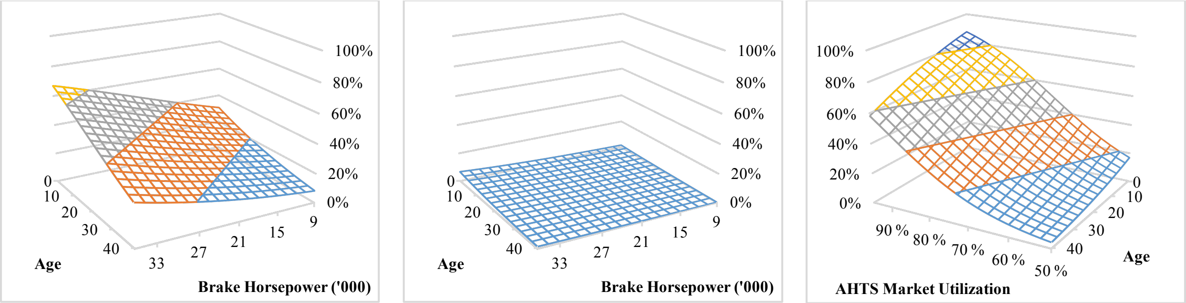


(d) Most suitable vessels spot (e) Least suitable vessels spot (f) Spot sensitivity to market condition

Figure 10: Probability of obtaining a contract in the AHTS term and spot market 2007-2016



(a) Most suitable vessels term (b) Least suitable vessels term (c) Term sensitivity to market condition



(d) Most suitable vessels spot (e) Least suitable vessels spot (f) Spot sensitivity to market condition

Figure 11: Probability of obtaining a contract in the AHTS term and spot market 2015-2016

6. Concluding remarks

In this thesis we investigated whether different vessel specifications affect an OSV's probability of obtaining a contract in the North Sea. In line with the hypotheses, age, vessel size and technical specifications are important determinants for obtaining contracts. There exist significant differences in determinants across vessel segments and contract types.

The results for the PSV segment coincides as younger vessels with large clear deck area built in Northwest Europe are preferred for both spot and term contracts. DP2 vessels dominate both markets and additional complexity is rewarded, while large bulk capacity are more suitable for the spot market. The probability of obtaining spot contracts is highly sensitive to vessel specifications, and having the most suitable vessel in terms of technical specifications is crucial for success. On the contrary, the suitable term market vessel is less sensitive to vessel specifications.

The preferences for AHTS vessels are significantly diversified when comparing the term and spot market. While younger and more powerful vessels built in Northwest Europe are more likely to obtain spot contracts, the term market is a two-tier market where either a less powerful and less complex vessel, or a more powerful and more complex vessel, is required to obtain contracts. Vessels with high complexity are significantly more likely to obtain spot contracts, with DP2 and ROV as rewarding features. While having the most suitable set of technical specifications increases the probability of obtaining contracts in both markets, it is particularly crucial in the spot market. On the contrary, the age and size of the vessel are less important determinants.

We acknowledge that there are some limitations in our study. First of all, as the raw data is sourced from external sources we cannot fully guarantee for the quality of the data. Second, the sourced data is subject to lack of desired information in terms of additional specifications of interest. Third, term contracts with long duration fixed in the early years of the sample are not representative of today's market, and may bias the results with regards to finding the most suitable term vessel. Finally, the volatile McFadden R^2 values may indicate that the determinants for obtaining contracts have been somewhat random in periods, especially in strong markets. This may infer that the model is more suitable for recent years, as high historic utilization makes it difficult to distinguish the impact of different vessel specifications.

We are certain that further research on determinants for obtaining contracts in the offshore supply market will improve the understanding of how the industry works. A possible next step is to extend our analysis by further investigating the determinants within vessel classes. Furthermore, investigating whether changes in the crude oil price affect the probability and determinants of obtaining contracts, would improve the ability to predict the demand for OSVs. Other possible areas for further research include the impact of changes in regulations imposed on the offshore industry, and whether the fuel efficiency and emission levels of the vessels affect the probability of obtaining a contract. In addition, applying the logit model to the drilling rig industry could yield interesting and useful results. However, a natural next step would be to investigate the market after the 2014 downturn into detail, in order to better predict the vessels' likelihood of fixtures going forward.

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Appendices

Appendix 1 – Summary of variables

		PSV		AHTS		
Variable	**Unit**	**Incl.**	**Exp. sign**	**Incl.**	**Exp. sign**	**Interpretation**
age	Years	X	-	X	-	Age of vessel on fixture date
bhp	Horsepower			X	+	Brake horsepower of vessel
deck	Square meters	X	+			Size of outside deck area
fexp	USD/day	X	-	X	-	Deviation in a vessel's daily fuel expenditure relative to fleet average
bulkcapacity	Cubic meters	X	+			Bulk capacity index for PSV
dp1		X	-	X	-	Dummy for whether vessel has DP1 system
dp2		X	+	X	+	Dummy for whether vessel has DP2 system
rov		X	-	X	+	Dummy for whether vessel has ROV
ic		X	+	X	+	Dummy for whether vessel has ice classification
fifi		X	+	X	+	Dummy for whether vessel has firefighting capabilities
helideck		X	+	X	+	Dummy for whether vessel has helideck
moonpool		X	+	X	+	Dummy for whether vessel has moonpool
nwe		X	+	X	+	Dummy for whether vessel is built in Northwest Europe

The dataset utilized also contains values for the following specifications:

Deadweight tonnage (DWT), length of vessel (LOA), beam of vessel, max draft of vessel, deck capacity, bollard pull, main crane capacity, passenger capacity and number of beds.

Appendix 2 – Correlation matrices

PSV

	age	deck	dwt	bhp	fexp	bulkcapacity	dp1	dp2	rov	ic	fifi	nwe	utilization
age	1.00												
deck	-0.10	1.00											
dwt	-0.20	0.89	1.00										
bhp	-0.26	0.82	0.77	1.00									
fexp	0.15	0.12	0.12	0.13	1.00								
bulkcapacity	-0.43	0.54	0.57	0.54	-0.06	1.00							
dp1	0.17	-0.35	-0.31	-0.35	0.04	-0.24	1.00						
dp2	-0.17	0.35	0.31	0.35	-0.04	0.24	-1.00	1.00					
rov	0.21	-0.17	-0.19	-0.14	0.04	-0.15	-0.03	0.03	1.00				
ic	-0.31	0.46	0.48	0.47	0.04	0.48	-0.17	0.17	-0.15	1.00			
fifi	-0.27	-0.21	-0.16	-0.14	-0.04	0.15	0.06	-0.06	-0.06	0.09	1.00		
nwe	0.20	0.12	0.08	0.07	-0.11	0.00	-0.02	0.02	0.09	0.08	-0.27	1.00	
utilization	-0.09	-0.04	-0.04	-0.05	0.02	-0.11	0.04	-0.04	0.02	-0.08	-0.04	0.04	1.00

AHTS

	age	deck	bhp	bp	fexp	dp1	dp2	rov	ic	fifi	helideck	moonpool	nwe	utilization
age	1.00													
deck	-0.32	1.00												
bhp	-0.39	0.85	1.00											
bp	-0.43	0.82	0.97	1.00										
fexp	-0.16	0.29	0.38	0.34	1.00									
dp1	0.58	-0.43	-0.45	-0.45	-0.11	1.00								
dp2	-0.58	0.43	0.45	0.45	0.11	-1.00	1.00							
rov	-0.33	0.52	0.65	0.67	0.25	-0.28	0.28	1.00						
ic	-0.15	0.15	0.15	0.18	0.10	-0.14	0.14	0.06	1.00					
fifi	0.17	-0.21	-0.29	-0.29	-0.09	0.16	-0.16	-0.38	-0.15	1.00				
helideck	0.07	0.19	0.19	0.17	-0.02	-0.08	0.08	0.09	0.14	0.00	1.00			
moonpool	-0.04	0.42	0.35	0.33	0.15	-0.14	0.14	0.32	-0.05	-0.15	0.56	1.00		
nwe	0.00	0.36	0.46	0.42	0.17	-0.24	0.24	0.33	0.13	-0.25	0.09	0.16	1.00	
utilization	-0.06	-0.04	-0.05	-0.05	0.03	0.02	-0.02	-0.04	-0.02	-0.01	0.01	0.01	0.00	1.00

Appendix 3 – Variation inflation factor tests

PSV Term Model

```
    Variable |       VIF       1/VIF
-------------+----------------------
        deck |      2.07    0.484039
bulkcapacity |      1.94    0.515899
         age |      1.53    0.652760
          ic |      1.51    0.660664
        fifi |      1.27    0.788367
         dp2 |      1.20    0.833648
         nwe |      1.16    0.859245
         rov |      1.11    0.903075
   fexp_type |      1.09    0.914560
 utilization |      1.06    0.946911
-------------+----------------------
    Mean VIF |      1.39
```

PSV Spot Model

```
    Variable |       VIF       1/VIF
-------------+----------------------
bulkcapacity |      2.56    0.390830
        deck |      2.09    0.478032
         age |      1.79    0.559326
          ic |      1.62    0.617098
        fifi |      1.57    0.634925
         nwe |      1.49    0.673306
         dp2 |      1.20    0.834443
   fexp_type |      1.14    0.876342
         rov |      1.11    0.900450
 utilization |      1.09    0.919887
-------------+----------------------
    Mean VIF |      1.57
```

AHTS Term Model

```
    Variable |       VIF       1/VIF
-------------+----------------------
         bhp |      2.59    0.385524
    moonpool |      2.09    0.478402
         age |      1.89    0.530365
         dp2 |      1.84    0.543006
    helideck |      1.81    0.551901
         rov |      1.76    0.567489
         nwe |      1.46    0.682629
   fexp_type |      1.24    0.806182
          ic |      1.19    0.843227
        fifi |      1.18    0.847236
 utilization |      1.03    0.974556
-------------+----------------------
    Mean VIF |      1.64
```

AHTS Spot Model

```
    Variable |       VIF       1/VIF
-------------+----------------------
         rov |      2.60    0.384235
         bhp |      2.48    0.403544
    moonpool |      1.44    0.695214
         age |      1.42    0.702977
    helideck |      1.40    0.715742
        fifi |      1.31    0.760857
         dp2 |      1.30    0.768743
         nwe |      1.26    0.790709
   fexp_type |      1.17    0.855939
          ic |      1.07    0.931979
 utilization |      1.03    0.968424
-------------+----------------------
    Mean VIF |      1.50
```