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Offshore freight rate determinants

A study of PSV term charter freight rates from 2004-2015

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Abstract

This master thesis investigates PSV term charter freight rates in the offshore industry. Fixtures in Brazil and the North Sea from 2004-2015 are examined. The offshore markets and term structure of freight rates are presented and discussed. Thereafter, the data and determinants of the freight rates are analyzed and later optimized. We find that both vessel and contract specific properties are significant determinants of the freight rate. Macro determinants are also found to be key variables in determination of the freight rate. Further, the periods before and after 2009 are compared in the analysis to identify whether the freight rate determination have changed during the last decade.

Preface

This master thesis is written as a concluding part of our Master of Science degree at the Norwegian School of Economics (NHH). The thesis is written in the field of our major in Finance.

Our choice of topic is based on our interest in the shipping and offshore industry. We have found it very interesting to investigate the determinants of offshore freight rates. Working with the thesis has been demanding process. Obtaining sufficient data proved to be the most challenging and time consuming. Yet, the effort has been rewarding and we are left with a greater understanding of the offshore market.

We would like to thank our supervisor Siri P. Strandenes for her guidance and constructive input when writing this thesis.

We would also like to thank Amund Høsøien at Nor-Ocean Offshore and Øivind W. Aanensen at R.G. Hagland Shipbrokers for their help with obtaining sufficient data and insight to the markets.

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1. Introduction

Offshore markets are a relatively fresh field of research. Finding relevant literature on the industry has been a difficult task, but has encouraged us to contribute to the field. We have been inspired by similar studies done in shipping and wanted to conduct similar research in offshore supply.

The petroleum industry is Norway's most important industry and the oil price development is a big part of the news. Norway's oil revenues and investments are decreasing and have put pressure on the petroleum industry to become more cost-efficient. With the offshore industry on the agenda more than ever we find it interesting to investigate the largest income source for oilfield service companies, the freight rates.

The purpose of this thesis is to investigate the determinants of freight rates paid for a Platform Supply Vessel (PSV). This has, as far as we know, never been researched empirically before. Our hypothesis is that there exist a relationship between vessel specifications and realized term contract freight rates. We also hypothesize that macro variables determine most of the term freight rates, and that contract specific elements explain the freight rate to a varying extent. The last research question we have examined, is whether the determinants of freight rates has changed in the aftermath of the financial crisis in 2008.

We have discussed freight rate determination thoroughly with market participants such as shipbrokers, oil companies and ship-owners. A common understanding among the market players is that vessel specifications determine a part of the term charter freight rates in the offshore supply market.

From a ship-owners' point of view, information concerning the role of vessel and duty specific factors in determination of freight rates can be used in strategic planning of operations and investments. Charterers can make use of information regarding when to hire a certain vessel and which vessel specifications a chartered vessel should have.

This thesis is divided into 8 chapters. A brief overview of relevant literature is presented in chapter 2. The offshore market is introduced in chapter 3. Chapter 4 will present the model and method used to analyze our data. The data is presented and described in chapter 5. Chapter 6 contains our analysis and findings. Chapter 7 points out criticism and limitations to the findings while chapter 8 concludes.

2. Literature review

Shipping freight rates have been investigated carefully in the past. Their seasonality patterns, volatility and term structure have been established as well as the macroeconomic determinants of shipping freight rates. While aggregate macro forecasts of freight rates can be argued to be useful for medium to long term investments, ship-owners and charterers could benefit from micro forecasts for making operational decisions, budgets and cash flow predictions.

However, the literature on microeconomic determinants of shipping freight is somewhat limited. Tamvakis and Thanopoulou (2000) found no significant difference between freight rates in the time period 1989-1996 for newer versus older vessels when investigating the existence of a two-tier dry-bulk ship charter market. Yet, in a more recent study Köhn and Thanopoluou (2011) finds that differences in freight rates for old and modern vessels are significant over a longer and more recent period. Vessel and voyage determinants of freight rates and contract times are investigated in Alizadeh and Talley (2011a) and Alizadeh and Talley (2011b) in dry bulk- and tanker markets respectively, using a system of simultaneous equations. For both shipping segments, freight rates are found to be positively related to the laycan[1] period and a simultaneous relationship exists between them. The laycan periods of freight contracts vary directly with freight rates and indirectly with freight rate volatility. Freight rates are positively related to the size of bulk ships, and single-hull tankers are traded at a discount. Freight rates and laycan periods also found to vary across shipping routes.

Similarly, the master thesis by Riise and Rødde (2014) tries to identify quality related aspects of freight rate determinants and existence of a quality premium in the dry bulk market from 2001-2014. They identify a non-linear relationship between the variables and support for quality segmentation with respect to age and size. They also find that there has been a shift in market dynamics in time periods before and after 2008.

Offshore freight rate research is a different story however. Bjørkelund (2014) empirically analyzes spot freight rate characteristics in the North Sea for both Anchor Handling Tug Supply (AHTS) vessels and PSVs and proposes a model to capture the market dynamics.

[1] The laycan period is the length of the period between the fixture and start date.

As far as we know, there has been no attempt to empirically analyze the term charter freight rates by studying their determinants. This is probably due to very limited data availability. After having obtained sufficient micro level data per fixture, we are able to analyze each specific term fixture for PSVs in both the North Sea and Brazil.

3. The offshore markets

Downstream logistics is defined as bringing oil and gas onshore while upstream logistics is defined as the supply of offshore installations (Aas et al., 2009). In order to operate from remote locations, offshore platforms and rigs need to be supported regularly by specialized vessels. Oil companies do not own these vessels, but charters them from ship-owners on contracts with different lengths. The hiring of these vessels is a large cost component in the upstream logistics for the oil companies.

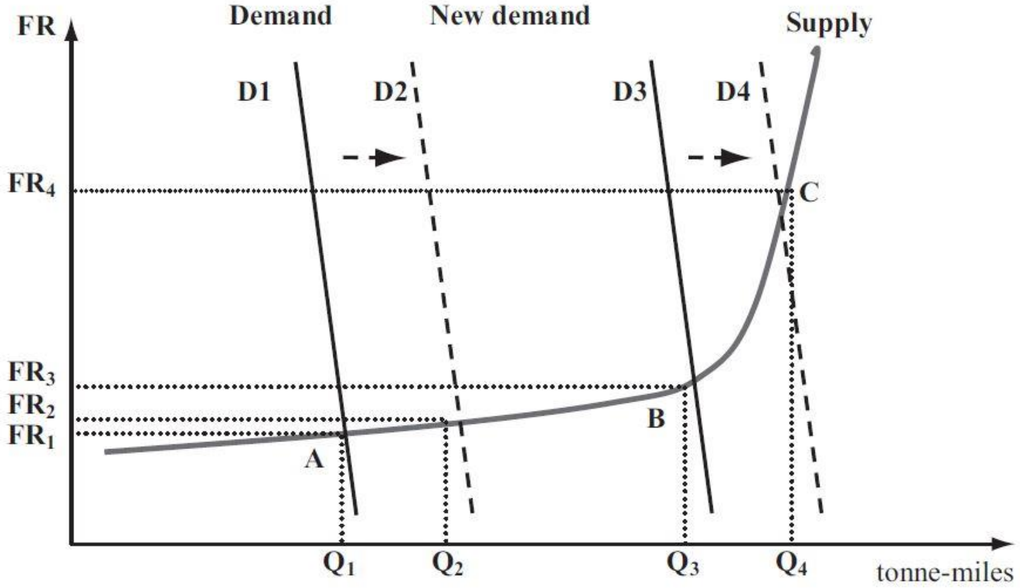
Optimization of the upstream logistics is called the vehicle routing problem. It will not be examined in this thesis, but is investigated and discussed in papers such as Azi et al. (2010), Halvorsen-Weare et al. (2012), Fagerholt and Lindstad (2000) and Brandão and Mercer (1997). Some important aspects are worth mentioning however. If the routing of vessels is poorly planned, installations would tie up more vessels and capacity than necessary, which drives unnecessary costs for the oil companies. Poor vessel routing may lead to high utilization of the current fleet, and thereby increased order books for new vessels as ship-owners believe the market is stronger than it actually is. However, this is economically inefficient since the required capacity with an optimized routing is actually less than the current capacity.

The offshore supply vessel (OSV) market is not a single global market, but more like a series of regional markets (ICS, 2011). Vessels can move around in search for work making it difficult to give an exact number of vessels in a particular region. In March 2015 the worldwide fleet count of PSVs was 2355 vessels (Clarkson's SIN, 2015). The same fleet amounted to 1187 in January 2004, having almost doubled the last 11 years.

3.1 Supply and demand in offshore markets

The offshore market is characterized by the interaction of supply and demand for services. The freight rates reflect, at any point of time, the balance between the supply and demand for offshore supply vessels. Alizadeh and Nomikos (2011) suggest the following short term supply-demand framework for dry bulk shipping freight rate determination:

Figure 3.1 Short Term Supply and Demand Framework, Alizadeh & Nomikos (2011)



Although Alizadeh and Nomikos (2011) studied the dry bulk market, these findings can be transferred to the offshore market. As the authors explain, demand is somewhat inelastic while the supply of shipping services has a convex shape due to the limitation of supply at any point in time. In the long term the supply curve can shift to the right when new vessels are delivered and to the left when vessels are scrapped. The convexity of the supply curve creates a supply function, which is, as shown in the figure above, elastic at low freight rate levels (FR_1, Q_1 to FR_2, Q_2) and very inelastic at very high freight rate levels (FR_3, Q_3 to FR_4, Q_4). Causing this shape of the supply curve is the excess supply of vessels when the market is in a trough. This occurs when vessels are unemployed, laid up and freight rates are very low. When these market conditions occur in the offshore supply market, a demand shock, for example bad weather or a huge oil spill, can be met by the excess fleet capacity and lead to rather low freight rate fluctuations.

If the market strengthens on the other hand, fewer vessels are unemployed or laid up. At the point of full utilization of the fleet, any additional supply increase in the short run is to bring in vessels from other offshore markets around the world or to reduce days in port. In such a scenario, the supply curve converges to a vertical line and becomes very inelastic. Subsequently, a change in demand would lead to considerable change in the freight rate.

The major demand driver for OSVs is the oil price and the worldwide demand for oil. A long-term and sustained increase in the oil price together with increased worldwide demand for oil makes it more attractive for oil companies to increase their production and exploration. However, as big projects also have a long lead time, it might take some time before an increased oil price will result in a higher demand for vessels (ICS, 2011).

Different offshore installations have different needs. Installations are usually separated into two types of units. Units moving around in search of oil and gas are called exploration or drilling rigs. Oil and gas producing units staying in the same position for an extended amount of time are called production platforms. Drilling rigs have a more uncertain demand than production platforms in general due to lower visibility. The supplies and stores needed to operate the platforms are to some extent predictable well into the future. It allows the oil companies to somewhat accurately calculate their yearly need of offshore supply vessels (ICS, 2011). To exemplify; two platforms installed 143 nautical miles ashore and spaced 26 nautical miles apart require 1500 tonnes of cargo every three days. If the oil company hires PSV vessels that are 3200 dead weight tonnes and sails in 13 knots, the two installation would tie up exactly two PSV vessels, which visits the installations every 2,5 days, in order to fulfil the cargo requirements (Adland, 2014b)

Exploration rigs' required support is a function of many factors. Most importantly is the distance from onshore to offshore location. As vessels more or less travel at the same speed, a rig closer to shore ties up fewer vessels than a rig further ashore. Other factors include the type and number of wells being drilled as well as the availability of vessels.

3.2 Spot and term contracts

The duration of a charter determines whether the contract is a spot, medium or long-term charter. A fixture with duration of less than 30 days is usually considered as a spot charter. Medium term is considered to be a fixture between a month and a year while a fixture longer than a year is considered to be a long-term charter. The freight rate is paid in arrears monthly for term contracts or upon redelivery in the spot market. The charterer pays for port costs, cargo dues, loading, discharging and fuel. Fuel tanks of vessel and cargo are shared between the ship-owner and charterer. The ship-owner pays for lube oil and other operating costs such as crew and insurances. Long term charters are concluded after a competitive tendering process to find the optimal vessel.

Spot charters are much simpler and fast paced compared to term chartering. Shipbrokers run the spot chartering process while the charterer makes the final vessel decision (Adland, 2014b). Spot contracts are usually fixed only a few days before start of operations and are re-negotiated every day. This means that today's freight rate isn't necessarily equal to tomorrow's freight rate, for a given contract. The North Sea has the only well-functioning spot market in the world today.

The spot market is well-functioning for the oil companies when there exist a permanent pool of available vessels waiting for charter. Excess supply of vessels in the spot market will result in low freight rates. For it to be well-functioning for a ship-owner, reasonable demand must exist in order to make it attractive for a ship-owner to have his vessel lying in a port with hopes of securing regular short-term employment. Even though ship-owners and oil companies have opposing interest it can be argued that some overcapacity in the market is beneficial. Norman (1980) suggested an economically efficient equilibrium for the tanker market where the value of one extra transport unit should be at least as valuable as the cargo value. Consider Norman`s equation

$$P\ (k`)\ \cdot v = b$$

where *P (k)* is the probability of too little capacity with fleet size *k*, *v* is the value to an oil company of one extra transport unit when transport capacity is scarce. Lastly, *b*, is the cost of providing one unit of transport capacity. The cost of transporting is generally lower than the cargo value, which implies that *b/v* is low and gives us an indication on how often we should expect to have overcapacity and a low freight rate environment.

Several ship-owners choose to have a large part of the fleet secured on long-term contracts and use the remaining vessels to play the spot market and take advantage of periods with excess demand and high day rates. The term charter market is a place where ship-owners and charterers allocate freight market risk according to their risk preference. The benefit of a long-term fixture is a predictable income stream. The downside is the risk of being paid a lower freight rate than one can achieve in the spot market. For a ship-owner, spot rates need to exceed long-term rates to compensate for days lying in port without work. There may be several reason to why ship-owners choose to operate their vessels in the spot market when term charter freight rates are higher than spot freight rates. It can be in hope of an increased spot freight rates, not being able to obtain a long-term charter or due to risk preferences. Oil companies will look at their required need for support and supplies to conduct their operations, and charter enough vessels on long-term charters to cover their anticipated daily needs. They will generally look to the spot market in the case of increased activity level, bad weather, oil spill or other demand shocks (ICS, 2011).

Building a vessel is a trade-off between a specialized and standardized vessel. Building a specialized vessel requires some certainty of a long-term charter. A vessel built on speculation for the spot market is usually a standardized vessel capable of performing services in several regions to a wide range of clients. If charterers prefer newer vessels on long-term charters it may influence the quality of vessels available in the spot market.

3.3 Term structure

3.3.1 Term structure in shipping and offshore markets

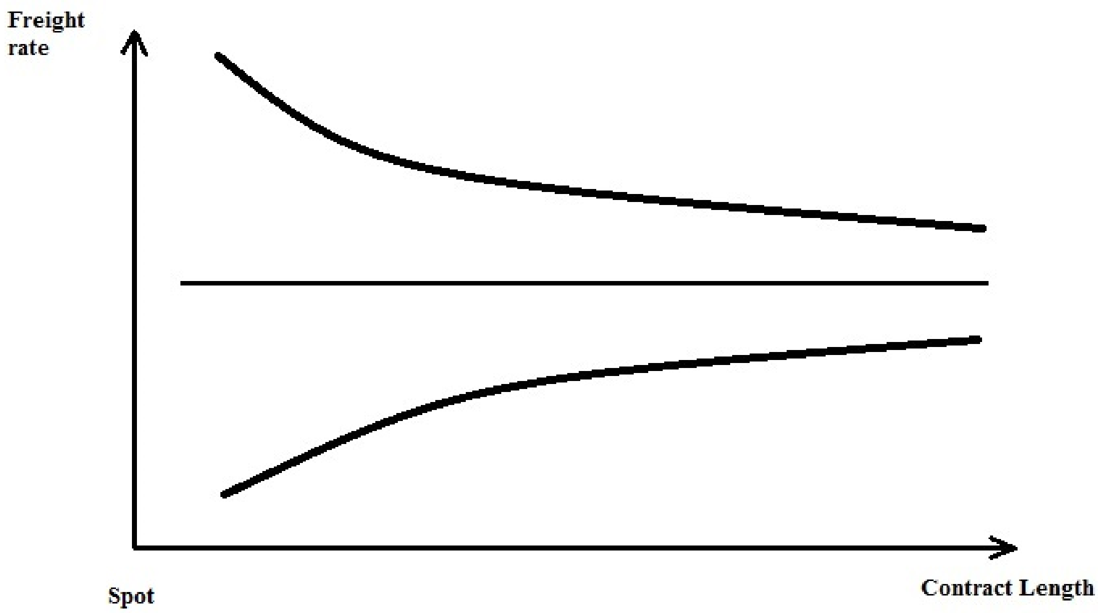
The relation between freight rates for comparable contracts, which differ only in duration, is called the term structure (Veenstra, 1999). It reflects the market's expectations about future spot freight rates and a time-varying risk premium (Strandenes, 2014). As Berg-Andreassen (1997) points out, the relationship between spot and term charter freight rates is of great practical importance for all stakeholders in the dry bulk market. A ship-owner can either charter out his ship on term contracts or a sequence of spot contracts, where the duration adds up to the term charter period. The ship-owner chooses the alternative with the highest present value after he has discounted it with his personal discount rate and risk preferences. In the dry bulk market, a considerable amount of speculators operate in the spot market. Hence, every arbitrage possibility are taken advantage of. This mechanism forces the term charter freight rates to eventually equal the present value of the expected spot freight rates. If one were to use the so called liquidity preference model, the market players requires an extra premium for taking a long-term contract to offset the loss of liquidity (Beenstock and Vergottis, 1993). Veenstra (1999) assumes this liquidity premium to be constant over time when he estimates his present value model. When using informal tests he finds that the present value model support the existence of a term structure.

When expectations show mean reversion, high freight rates are expected to fall and low freight rates are expected to rise. Strandenes (1999) assumes that market participants have semi-rational expectations, i.e. they have an opinion of the direction of the mean reversion process, but not the actual path and models the term structure as a weighted average of the time charter equivalent of the spot rate and the long run equilibrium freight rate. Consider Strandenes' (1999) formula:

$$tc_{i,d} = \gamma_{i,d}\pi_i + \mu_{i,d}\overline{\pi}_i \quad \forall i, d$$

where γ is the weight of voyage result π (time charter equivalent, TCE). μ is the weight of long-term μ for equilibrium TCE π bar. i is the type of vessel i = t,b and d is the duration of time charter; < 1 year, 1-3 years, > 3 years. The importance of current conditions is reduced when the duration of the contract increases. The weight for the current freight rates γ is high for time charter contracts of short duration compared to the weight for long-term equilibrium freight rate μ. Hence the term structure can be modeled as presented in the figure below.

Figure 3.2 The Term Structure, Strandenes (1984)



Although the PSV market differs in some ways from the dry bulk we assume that the term structure theory from the dry bulk market can be transferred to the offshore market. According to shipbrokers, vessels on term charter contracts have a tendency to be unnoticed by all other charterers than the current client because the spot market also function as a "showcase" where charterers can gain experience with different vessels and their ship-owner. Having a vessel on a long-term contract can therefore be regarded as a liquidity loss for a ship-owner.

Freight rate fluctuations are primarily due to changes in demand due to fixed supply in the very short run. Demand can't always be predicted perfectly and leads to a periodic mismatch with fleet size and increased volatility. Freight rate expectations may become self-fulfilling if all parties expect spot freight rates to increase next week, for example due to bad weather forecasts. Ship-owners would hold back vessels in anticipation of higher freight rates while charterers would want to fix vessels prior to the increased freight rates. The outcome is a rise in demand, decreased supply of vessels, and a higher spot freight rate today (Strandenes, 2014). This is probably the main reason why we can observe long periods of increasing or decreasing freight rates.

Kavussanos and Alizadeh (2002) discuss whether the term- and spot freight rates are related through the expectations hypothesis of the term structure (EHTS). According to the expectation hypothesis, time charter freight rates in a particular period should reflect the weighted average of spot freight rates in the same period. This is, however, based on the assumption that freight markets operate efficiently. Although the efficiency of the PSV-market will not be tested in this thesis, we do not believe that the market is efficiently enough for the expectations hypothesis of the term structure to be true.

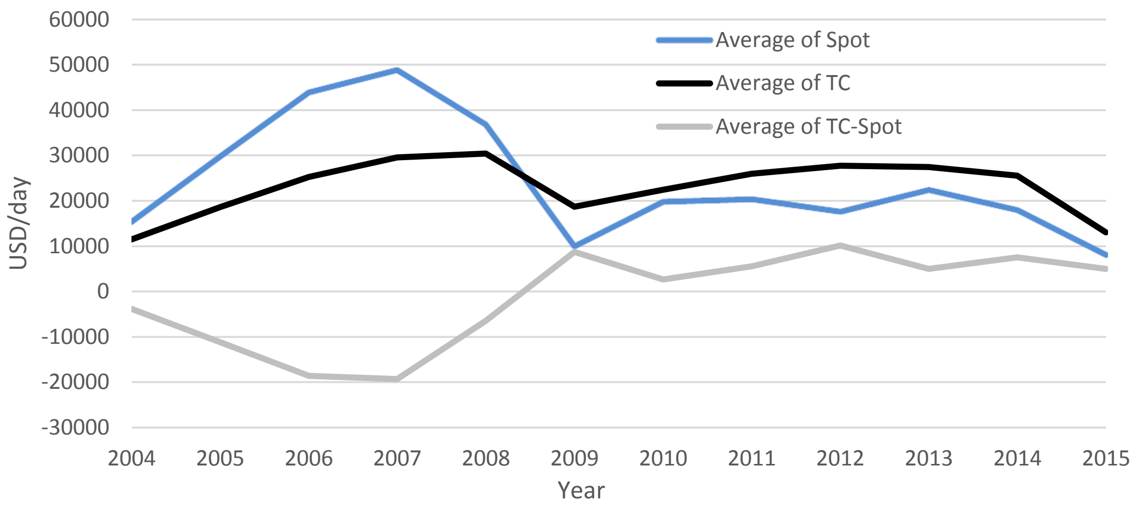
Based on Kavussanos and Alizadeh's (2002) paper we can assume that time charter freight rates are a type of forward rates. Consequently, we can construct a forward curve with our dataset by comparing spot- and term charter freight rates with different durations. Hence, we can characterize whether the market is normal, in contango or backwardated. Contango occurs when the spot freight rate is below the term charter freight rates. Conversely, backwardation exists when the spot freight rates are higher than the term charter freight rates.

Not being able to hire a vessel can become very costly for oil companies. The costs of temporarily shutting down or postponing work on a platform are enormous. Therefore, if a platform is dependent on supply from a vessel to continue its work, an oil company's willingness to pay is extremely high. One can compare the historical spot- and term charter freight rates with the commodity markets to analyze the forward curve. Backwardation in commodity markets occurs when there exists a shortage of the commodity for immediate delivery. Hence, a temporarily price premium may occur, as buyers' willingness to pay for the commodity increases with the shortage of the commodity. This happens in the offshore supply industry when there is shortage of available vessels combined with high seasonal demand or bad weather. On the other hand, markets are in the long term likely to mean revert (Strandenes, 1984) offering a discount in prices as the market converge to its long term equilibrium.

Transferring this to the offshore supply market, one can compare the convergence to contango in the commodities markets with more available vessels in the offshore supply market.

As shown in Figure 3.3, the market was in backwardation from 2004 and throughout 2008. Contrariwise, the market shifted to contango in the aftermath of the financial crisis.

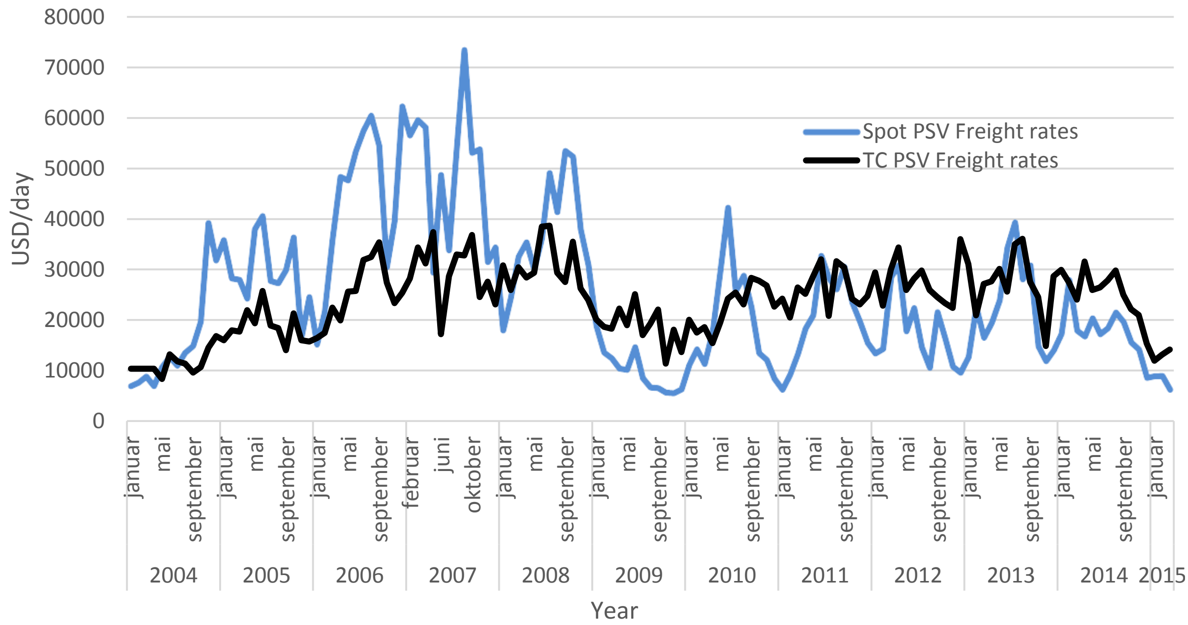
Figure 3.3 Average Yearly Freight Rates



We find the point of intersection in January of 2009 as quite interesting. In chapter 6 we have analyzed and compared the period before and after 2009 in relation to our hypothesis regarding vessel specifications, contract characteristics and macroeconomic variables. The point of intersection is also visible in Figure 3.4, where the spot- and term charter freight rates are displayed as monthly averages.

Berg-Andreassen (1997): "Although normally not always well articulated in the shipping industry, the spot rate is assumed to impact the prevailing expectations of term charter freight rate movements". Even though there exists several studies of the term structure in the tanker- and dry bulk markets, such studies are of no existence in the offshore supply market as far as we know. This shortfall may be explained by lack of sufficient data. However, as Berg-Andreassen (1997) points out, "the most common shipping industry perception is that the changes in the spot rate are the basis for the formation of the expectation of the term charter freight rates". Zannetos (1966) found that the spot freight rate is an important determinant of the term charter freight rate. To quote Zannetos (1966): "In summary, the long-term freight rates are expected to move in the same direction as the short-term rates, but will not exhibit the erratic fluctuations of the spot rate".

Figure 3.4 Average Monthly Freight Rates

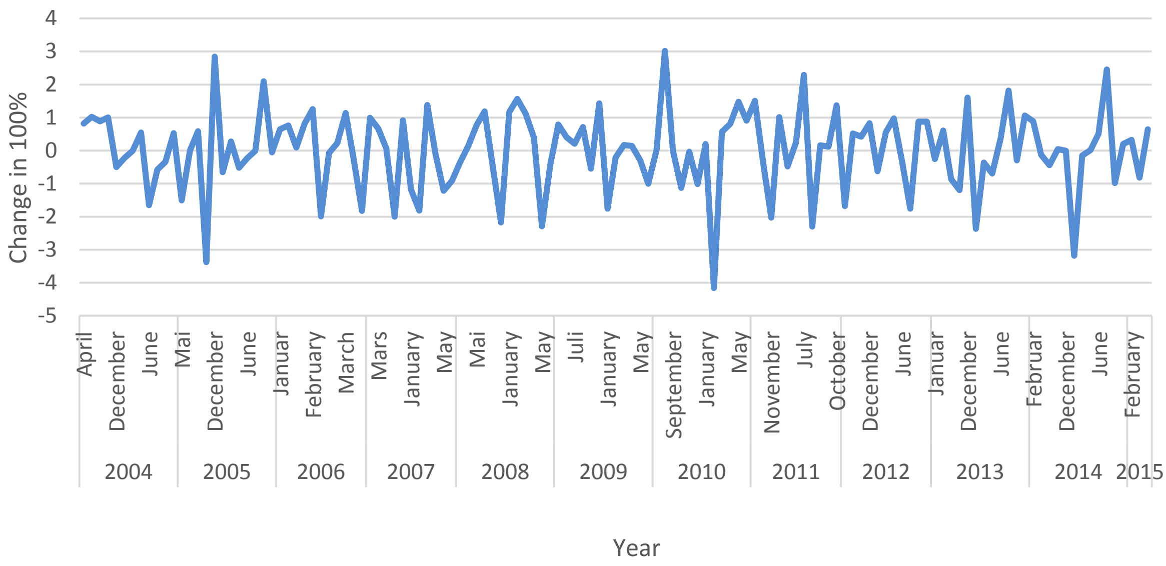


By studying Figure 3.4, one can see some of the same relation as Zannetos (1966) mention in his book; the term charter freight rates are moving in the same direction as the spot freight rate. However, the unpredictable spot freight rate fluctuations are not as present in the term charter freight rates. One can also notice that the spot charter freight rate fluctuations are quite extreme in the period from 2004-2009 and less volatile from 2009-2015. This may be caused by the ship-owners' aggressive contracting of new vessels in the aftermath of the financial crisis, hence the supply curve shifted to the right in the latter period.

3.3.2 The term structure as a credit spread

The term structure theory of freight rates has some of the same characteristics as the term structure theory of interest rates. Hale and Vanags (1989) base their studies of the relationship between term- and spot charter freight rates to be similar as the relationship between the long- and short term interest rates in the financial markets. The authors modified the bond model found in Shiller (1979) and found that the variations in a one year term charter contract should be a function of the spread between long- and short term freight rates. In the figure below, we have constructed the relative spread between term- and spot charter freight rates in the period from 2004 to mid-march 2015.

Figure 3.5 Monthly Term and Spot Charter Spread



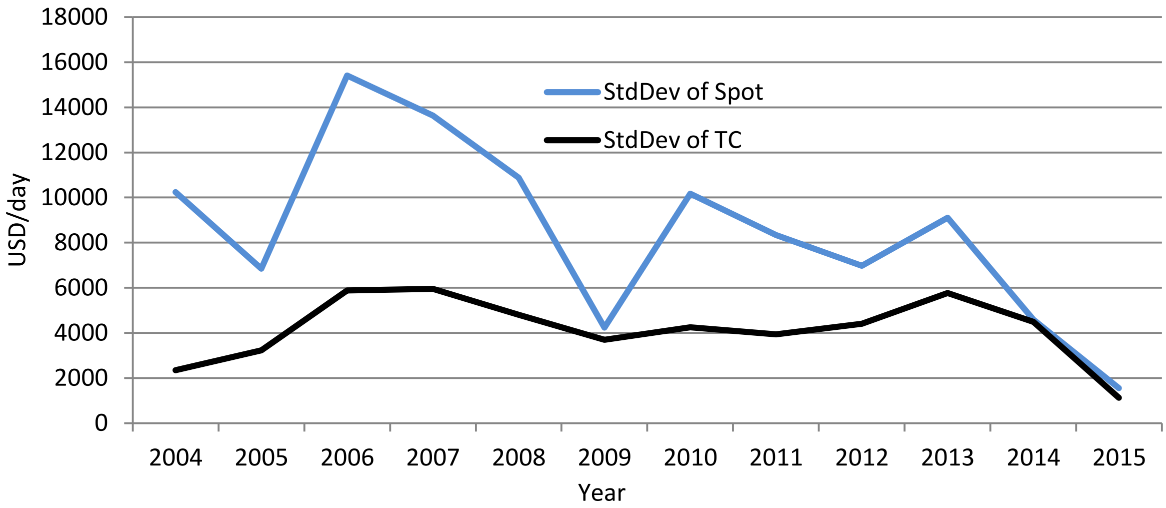
As Figure 3.5 illustrates, the spread has been quite extensive, varying between positive 300% to negative 400% in the examined period. It is worth mentioning that Hale and Vanags (1989) points out that the expectations theory did not hold for the dry bulk market in early 1980's.

3.3.3 Risk premium in the term structure?

Kavussanos (1996) compares the risk premiums between spot- and term charter freight rates in the dry bulk market between 1973 and 1992. He observed that the volatility, in general, was higher in the term charter market than in the spot market. The author argues that term charter freight rates may be more sensitive to changing perceptions as they reflect the future market. When the market is in a trough and the charterers are sensing an upcoming upturn, they rush to fix vessels on term charter contracts. Consequently, the time charter freight rates move upwards more rapidly compared to the spot charter freight rates. Conversely, if the market is peaking, charters would urge to fix vessels on spot charter contracts. Hence, the shortage of demand for time charter contracts results in a sudden decrease in time charter freight rates.

Comparing Kavussanos' (1996) findings to the offshore supply market, one can't state that the volatility in the term charter market is greater than in the spot charter market. Referring to Figure 3.4, we can observe that the volatility of the spot market freight rates are greater than the term charter freight rates' volatility. To picture this even further, we calculated the standard deviations from the monthly average spot- and term charter freight rates between 2004 and mid-march 2015. As shown in Figure 3.6 below, the standard deviations in the spot market exceeds the ones in the term charter market over the whole period. However, since the summer of 2014, when the oil price decreased substantially, the standard deviations in the two markets have plummeted and converged towards each other. The standard deviations also converged towards each other during the financial crisis in 2008/2009, which might imply that spot- and term charter freight rates' standard deviations are converging when the market is in a trough. We find these converging events as very interesting and believe them to be natural ends of a cycle; hence we will analyze and compare the periods in chapter 6.5.

Figure 3.6 Monthly Average Standard Deviations



3.4 Vessel characteristics

Vessels used are generally divided into two groups: Platform Supply Vessels and Anchor Handling Tug Supply vessels. They have some main characteristics that separate them from each other. A PSV vessel is predominantly designed to transport cargo to and from an offshore installation. In order to ensure continuous production and exploration offshore, the platforms and rigs need to be supplied by PSVs on a regular basis. The single most important property of a PSV is its carrying capacity. Supplied cargo can be separated into deck cargo, which is cargo transported on the deck of the vessel, and bulk cargo transported in the tanks below deck. Deck cargo can be drilling pipes or food. Bulk cargo can be drilling mud, water and other fluids needed to produce or drill for oil and gas. Supply vessels do not only transport cargo to installations but carries return cargo like empty containers and dirty drilling mud back to shore.

Installations are usually visited by a PSV a few times a week. Oil companies try to serve several installations using the same vessel in order to obtain good utilization of the vessels. Especially when installations form a cluster it becomes cost-effective to share a vessel.

An AHTS vessel is designed to anchor, tow and move drilling rigs from one location to another. These vessels also have a clear deck area and on-board tanks for fluids. Therefore they may in some situations be used as substitutes for PSVs. However, they do not compete under normal market conditions. The most important properties of an AHTS vessel are its bollard pull (BP) and brake horsepower (BHP).

The development of both AHTS- and PSV vessels has been incremental over the last decade. Due to more ultra-deep-water (UDW) drilling and drilling in harsh environments, the demand for larger and more powerful OSVs has increased. Harsh weather conditions in the North Sea and Brazil as well as offshore activities taking place further ashore makes the supply of installations very demanding. Newer vessels are often multi-functional, weather adapted and capable of carrying a variety of cargo in more segregated tanks. A trade-off is present when deciding how to configure a fleet. Economies of scale exists when using larger vessels while a fleet of many smaller ships is more flexible under demand shocks (Adland, 2014a).

3.5 Charter dates

Two important dates exist in a vessel contract. The fixture date is the date on which the contract negotiations between the ship-owner and charterer are finalized. The second date is the date on which the vessels must present herself ready to start operations. Once the startup day for the supply operation has been determined by the charterer, he will enter the market to find the most suitable vessel for the work to be conducted. The length of the laycan period may vary with the scope of work, geographical area and the supply and demand conditions in the market. Assuming vessels are available at all times, the charterer can wait until the last minute before hiring a vessel. This is likely to happen if conditions are not favorable and the charterer still has time to wait before operations start. The charterer’s decision of when to charter a vessel depends on current and expected market conditions, the volatility of rates and risk of having to pay excess freight rates if supply is inelastic.

4. Model

In order to investigate the term charter freight rates determinants, the following general model is implemented:

FR = (vessel specifications, contract specifications, macroeconomic variables) (1)

where FR is the freight rate for the term contract, vessel specifications are vessel specific properties, contract specifications are contract specific characteristics and macroeconomic variables are broader variables thought to indirectly influence the freight rate.

The following model is specified to test the relationship between anticipated determinants and the freight rate:

$$FR_{i,t} = \beta_0 + \beta_1 M^2 i + \beta_2 BHPi + \beta_3 DWTi + \beta_4 DP2i - \beta_5 AGEi - \beta_6 DURATIONi + \beta_7 DAYSFORWARDi - \beta_8 PRODi - \beta_9 DRILLi + \beta_{10} BRAZILi + \beta_{11} OILPi + \beta_{12} SPOTi + \beta_{13} WORLDOILPi \quad (2)$$

where FR*i,t* is the freight rate of the *i*th fixture (contract) at time *t*. M^2i is the size of the deck area measured in square meters. BHP*i* is the vessel's brake horsepower. DWT*i* is the vessel's carrying capacity measured in deadweight tons. DP2*i* is a dummy variable distinguishing between vessel with dynamic positioning system 2 or not. AGE*i* indicates the age of the vessel at the fixture date. DURATION*i* is the length of contract *i* at the fixture date. DAYSFORWARD*i* is the length of the period from the fixture date to start date. The dummy variable PROD*i* is identifying whether the scope of work is production support or not. DRILL*i* has the same function as PROD*i* except it is drilling support in this case. The dummy variable BRAZIL*i* is identifying if the fixture is in Brazil or the North Sea. Furthermore, to control for macro determinants of freight rates in the model, we have included the monthly average spot freight rate, SPOT*i*, which serves as an indicator for the condition in the PSV freight market. OILP*i* is the price if one barrel of Brent crude oil at the fixture date. WORLDOILP*i* is the worldwide monthly oil production at the fixture date.

4.1 Model arguments

The inspiration for the model specification was primarily Alizadeh and Talley's (2011) paper. Some of the same micro determinants are included in our model. We have added other micro and macro variables believed to be significant determinants of the term charter freight rate.

As previously mentioned, a PSVs carrying capacity is its single most important property. Charterers' demand may fluctuate, which makes deck area flexibility valuable to the oil companies. In the case of bad weather, one can't fully load a vessel with cargo because of safety regulations. Thus, a vessel with a large deck area may be able to fulfil the charterer's supply requirements. A larger deck area entails the opportunity to carry more cargo which implies economies of scale for both the charterer and the ship-owner. Offshore installations also demand more supplies than previous years due to their technological development. On the other hand, installations have limited storage capacity, hence vessels may not always utilize a large deck area. Obtaining carrying capacity for bulk cargo has not been successful. However, we find it reasonable to assume that a larger deck area implies a larger bulk cargo carrying capacity. We suspect deck area and DWT to have a high positive correlation, but decided to include both in the model considering that they differ somewhat in what they measure. Deck area is a vessel's storage area while DWT is the carrying capacity in tons. Consequently, we believe that increased deck area and DWT is positively related to the freight rate.

Engine size is believed to positively influence the rate. A stronger engine is capable of performing more complex operations in a reliable and safe manner in line with the oil companies' strict health, safety and environment requirements. The risk of accidents or injuries is assumed to be lower with larger engines because of their capability to withstand harsher environments. Aas et al. (2009) suggest that the biggest bottleneck in upstream logistics is the vessels ability to safely conduct operations in big waves. We suspect there to be a high correlation between BHP, deck area and DWT, but given that they measure different vessel features we decide to include all specifications in the model.

DP-class is included in the model as we believe charterers value a higher DP-class in the same way they value brake horsepower. A higher DP-class is able to sustain harsher weather conditions much like BHP. We expect there to be some correlation between them. We also expect there to exist high negative correlation between DP-class and vessel age as increased

DP-class has come with time. However, many older vessels have upgraded their DP-class to meet charterers' requirements.

Vessel age is expected to be a significant determinant of term charter freight rates. Specifically, we expect newer vessels to be compensated for satisfying charterers' requirements in terms of environmental friendliness, safety and efficiency. Hence, the vessel age coefficient is expected to have a negative impact on the term charter freight rate.

We expect the contract length to be negatively related to the freight rate. A longer contract provides a secure and predictable cash flow and should make the ship-owner willing to accept a lower daily freight rate. However, Veenstra (1999), argue that there exists a constant liquidity premium in the term charter freight rates due to the loss of liquidity for the ship-owner. As discussed earlier, shipbrokers claims that vessels on long term charter contracts may be forgotten by charterers as they are not active in the spot market.

Predicting number of days forward's influence on the freight rate is not straightforward, but will be interesting to explore. Alizadeh and Talley (2011b) find a positive relationship between the laycan period and the freight rate. They believe it suggest that there is a premium when hiring a vessel early. This might also be the case in PSV market. On the other hand, we suspect the last vessel out of port to achieve a higher freight rate if it is the last available vessel.

The dummies for scope of work is inspired by Alizadeh and Talley's (2011b) route dummy variables. In the same way tanker freight rates may vary with the routes, PSV freight rates may vary with the scope of work. We expect vessels on production support to receive significantly lower freight rates than other scopes of work. As previously mentioned, the need for production support is quite predictable into the future and vessels are often fixed on long-term contracts. These vessels are often standardized vessels capable of performing basic operations.

Vessels on drilling support are expected to receive higher freight rates than vessels on production support, but lower freight rates than vessels on other scopes of work. Drilling contracts are often based on a well-by-well basis, making them shorter in duration than the production contracts. Drilling contracts may also consists of more uncertainty as it is harder for oil companies to estimate the need for cargo transportation to an offshore drilling rig.

Freight rates are expected to be higher in Brazil due to stricter local laws and legislation which makes it costly to operate a supply vessel in the region. The inflation in operational costs, taxes and stricter laws started in the late 2000’s. It is important to mention that although we expect freight rates to be higher in Brazil, it does not necessarily mean higher earnings for the ship-owner. On the other hand, freight rates in the North Sea are believed to be affected by the high cost level in the region. As ICS (2011) states: “the cost varies significantly from country to country and region to region, to the extent that is becomes almost impossible to define a unified worldwide rate level for a particular class of OSV”. The environmental conditions are somewhat different between the two regions. Weather conditions are generally worse in the North Sea while Brazil has more demanding UDW drilling.

We are confident that the price of oil will prove to be a significant determinant of the freight rate, but are curious to find out to what degree. As previously mentioned, an increased oil price is likely to increase oil companies’ oil production and demand for vessels. This is expected to increase the freight rates.

The freight rate is obviously related to the general average monthly PSV rate. As discussed in chapter 3, the freight market shifted from backwardation to contango in January 2009. We believe the term charter freight rates to reflect the underlying trend and expectations in the freight rates. The spot freight rate is expected to be a measure of the current temperature in the market. The spot freight rates are expected to have a positive relationship with the term charter freight rates. The magnitude of the influence is uncertain and may be time-varying.

In addition, as a macro variable, the worldwide monthly oil production is included in the model. We find it natural to believe that an increased production and exploration of crude oil should lead to higher demand for offshore supply services and vessels. The higher demand, all else equal, implies higher term charter freight rates until the demand-shock is offset by increased supply. We suspect the worldwide monthly oil production to be positively correlated with the crude oil price.

4.2 Method

To perform the analysis we will apply the information we have obtained to estimate a function which may determine the freight rate. To explain the effect different variables have on the freight rate we will avail ourselves of OLS regression analysis. Based on the results we will have empirical evidence which either supports or rejects our assumptions of the freight rate determination. Six primary regression assumptions need to be met in order to make our model applicable.

1. Linearity - There should be a linear relationship between the dependent and independent variables.

2. Independence of errors - The error terms are uncorrelated with each other. No autocorrelation or serial correlation.

3. Homoscedasticity - The residuals variances is constant over the regressions surface, i.e. the variances along the line of best fit remain similar as you move along the line. No heteroscedasticity.

4. No multicollinearity - No independent variable has a perfect linear relationship with any of the other independent variables.

5. The independent variables are uncorrelated with the error term.

6. Normality - Errors should be normally distributed.

Tests for these assumptions will be carried out after the regressions in order to assess the validity of our input and findings.

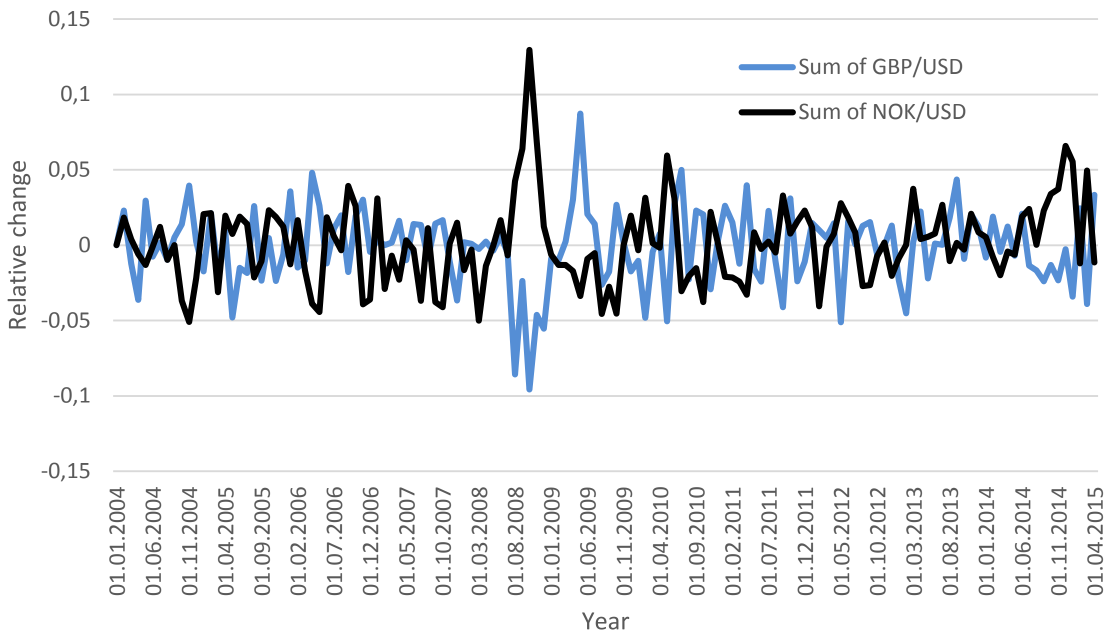
5. Data

The data used in this analysis was not obtained from a public database. The data originates from a database created and shared only by shipbrokers and oil companies. As several oil companies and shipbrokers were excited by our thesis topic, we were allowed access to the database. The data contains fixture information from the period January 2004 to March 2015. As previously stated, we have chosen to analyze PSV term charter freight rates. Each fixture in the sample includes information such as vessel characteristics, scope of work, charterer and ship-owner. A significant share, 500, of the fixtures was omitted due to lack of a freight rate. The emittance of these fixtures may lead to some faulty conclusions. However, these fixtures are evenly spread out through the analysis period, and between various charter parties and regions. Due to this we do not expect that the emittance of these fixtures will lead to any invalid results. Two fixtures were omitted because of their short contract durations clearly classifying them as spot fixtures. We also merged some fixtures since some clients changed names during a contract period which made one unique contract appear as two separate ones. For example, StatoilHydro changed name to Statoil during the examination period. After filtering the data for missing freight rates and double observations we were left with 1187 fixtures for our analysis. Specifically, the information on each contract includes vessel name, work region and country, activity, client, manager, fixture date, start date, end date, US dollar rate, brake horsepower and deadweight tonnage. A fragment of the raw data can be found in Appendix 1. We also added year built, oil price, deck area, DP-class, monthly worldwide oil production and monthly average spot PSV freight rate to each fixture in the sample as we believe these variables may impact the determination of the freight rates.

5.1 The freight rate

The term charter freight rate is the dependent variable in our analysis. It is expressed as the day rate to be paid from the charterer to the ship-owner. Most freight rates in our data have been agreed in US dollar. Even though some contracts have been agreed in Pounds Sterling (GBP) and Norwegian Kroner (NOK), all freight rates in our data are expressed in USD. The currencies were converted to USD before we received the data by using the exchange rate on the fixture date. Figure 5.1 shows the exchange rates development between USD and NOK, and USD and GBP. As they have moved within the same spectrum we will not do any additional adjustment to the data.

Figure 5.1 Relative Currency Change, NB (2015) and GV (2015)



5.2 Independent variables

In order to investigate the determinants of term contract freight rates we have included both micro- and macroeconomic variables. Microeconomic variables are captured through vessel and contract specifications. Macroeconomic variables are added to describe market conditions and sentiment.

Vessel specifications:

- Deck area
- BHP
- DWT
- DP-class
- Age

Contract specifications:

- Contract duration
- Number of days forward
- Scope of work

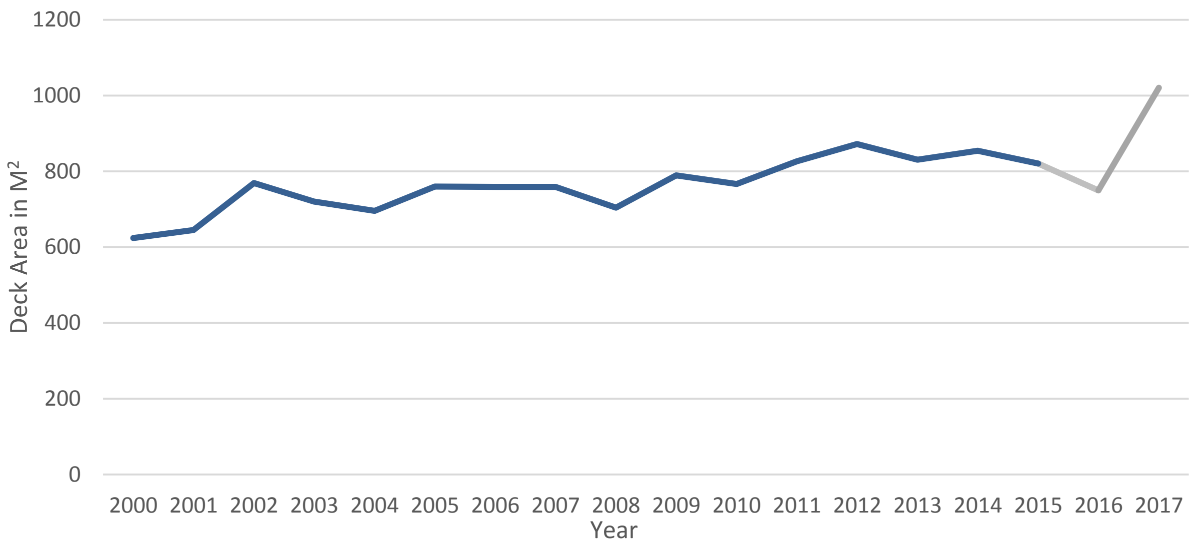
- Region

Macroeconomic variables:

- Oil price
- Average monthly spot freight rate
- Worldwide oil production

Deck area was added manually to each fixture using additional databases provided by the shipbrokers. It is measured in square meters and is very important property for PSVs. Figure 5.2 displays the deck area development of built vessels the past 15 years and the order book in the coming two years. It shows an upward trend in the average deck size of new buildings. The average deck area lied between 600m^2 and 800m^2 up until 2010, but has consistently been above 800m^2 since then.

Figure 5.2 Deck area development

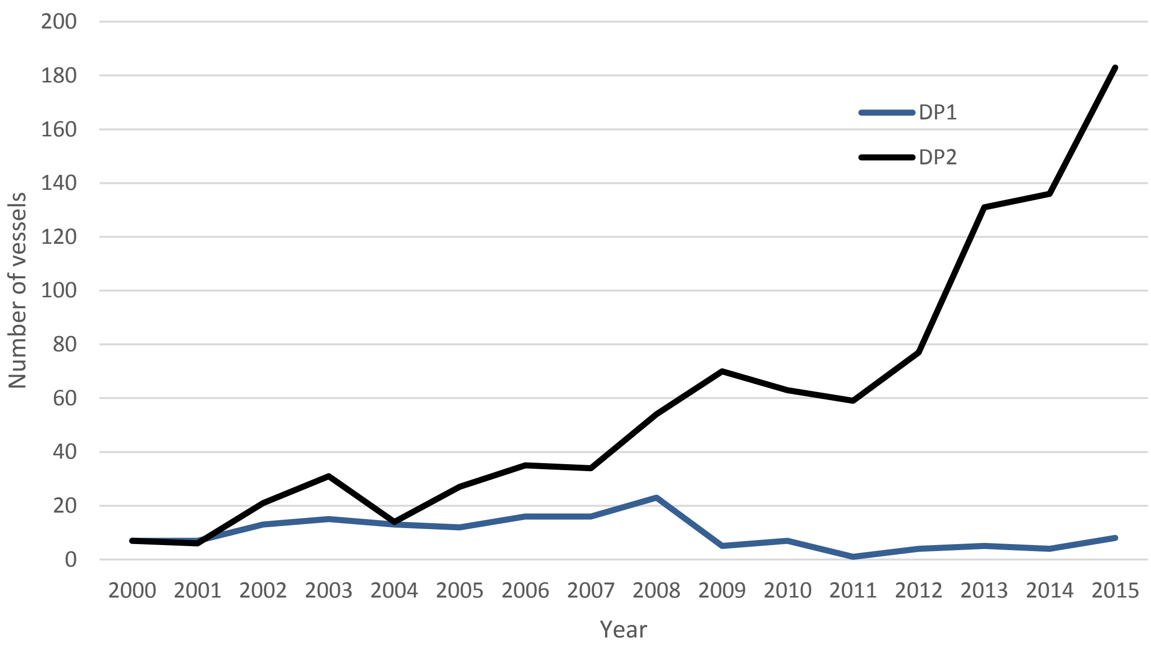


Brake horsepower is the measure of the vessel's engine power.

Deadweight tonnage is the measure of the weight in tons the vessel can carry. It includes all cargo, fuel, supplies, and passengers. It does not include the weight of the vessel.

Dynamic positioning (DP) is a computer system used to automatically maintain a vessels position over the ground or relative to another moving unit by using its propellers and thrusters. The system uses position sensors, motion sensors, and wind sensors. The DP class can be 0, 1, 2 and 3 where quality increases with the number. The DP-class does also indicate a vessel's ability to operate in harsh weather. A vessel with DP2 can operate safely in significantly harsher weather and wave conditions than a vessel with DP1. Only a few vessels in our study does not have a DP-system, all of which are old vessels. As it is a necessity for offshore vessel to have a DP-system today, all new buildings have a DP-class. Figure 5.3 illustrates the amount of vessels built with the different DP-classes each year. It appears that close to all new buildings the past decade are equipped with DP2.

Figure 5.3 DP development



Year built was added manually to each fixture using additional databases. Year built has been generalized by assuming that each vessel, on average, was delivered in the middle of the year, i.e. 1. July. For each fixture, the difference between year built and fixture date equals the vessel age.

The contract length is measured in days from start to end date. Term charter contract durations can be anywhere between 4 weeks and a decade.

Number of days forward is measured as the difference between the fixture and start date. It is the length of the period from the contract is fixed until the contract starts. It can be anything from zero days to several years.

Vessels are hired to perform various duties. The most pronounced scopes of work are construction support, drilling support and production support. There are also other scopes of work such as spill response, well stimulation, firefighting, standby and seismic support.

The region in our study is either Brazil or the North Sea. 270 fixtures are in Brazil and 917 are in the North Sea.

As stated in previous chapters, the oil price is the single most important demand driver for supply vessels. We obtained the monthly average Europe Brent Spot Price/barrel from EIA (2015a). The monthly average oil price in the fixture month was added to each fixture.

We used our data sample of all spot PSV fixtures to create a monthly average for each month in our analysis period. We added the corresponding monthly average spot freight rate to the fixture date.

The worldwide oil production was added to our data from EIA (2015b). The variable is measured in standard cubic meters.

5.3 Descriptive statistics

Table 5.1 Correlation Matrix

	TC FR	**M^2**	**BHP**	**DWT**	**DP2**	**Age**	**Duration**	**Days Forward**	**Production**	**Drilling**	**Brazil**	**Oil Price**	**Monthly Spot**	**Oil Production**
TC FR	**1**													
M^2	0,27	**1**												
BHP	0,24	0,71	**1**											
DWT	0,25	0,87	0,69	**1**										
DP2	0,24	0,39	0,40	0,36	**1**									
Age	-0,17	-0,02	-0,30	-0,31	0,47	**1**								
Duration	0,00	-0,01	-0,05	-0,07	0,06	-0,17	**1**							
Days Forward	0,14	0,10	0,15	0,12	0,05	-0,25	0,52	**1**						
Production	-0,23	0,03	0,07	0,03	0,05	0,05	-0,02	-0,15	**1**					
Drilling	0,06	0,01	-0,06	0,04	0,03	-0,15	0,07	0,10	-0,78	**1**				
Brazil	0,11	-0,34	-0,31	-0,29	0,14	0,01	0,57	0,26	-0,15	0,16	**1**			
Oil Price	0,37	0,13	0,08	0,11	0,14	-0,06	0,06	0,05	-0,11	0,10	0,17	**1**		
Monthly Spot	0,30	-0,09	-0,08	-0,07	0,10	0,07	-0,04	0,06	-0,01	0,06	-0,16	-0,13	**1**	
Oil Production	0,08	0,22	0,21	0,20	0,18	-0,05	0,00	0,02	-0,04	0,08	0,12	0,50	-0,39	**1**

Table 5.2 Descriptive Statistics

Stats	TC FR	M^2	BHP	DWT	Age	Duration	Days Forward	Oil Price	Monthly Spot	Oil Production
Mean	24275	802	7374	3871	7	610	91	85	24453	415017
Median	23666	820	6690	3800	5	259	21	82	20967	411821
Max	91667	1270	15791	7620	32	3836	1878	133	73482	454951
Min	5586	200	2250	951	-5	28	0	31	5579	386605
SD	9833	178	2318	961	8	733	210	25	14264	13837
SD / Mean	0,41	0,22	0,31	0,25	1,08	1,20	2,32	0,29	0,58	0,03
Skewness	1,10	-0,37	0,60	0,04	1,22	1,65	4,39	-0,11	1,03	0,82
Kurtosis	6,17	2,82	2,91	3,91	3,93	5,25	26,12	1,82	3,65	3,18

Table 5.1 displays the correlation between our variables. Table 5.2 displays the descriptive statistics of our data. The average freight rate in our sample is 24.274,5 USD. The maximum freight rate is given to a vessel on a half-year contract in the North Sea in the latter part of 2007. The second highest freight rate was 15.000 USD lower, indicating that it was a particularly high freight rate. Referring to Figure 3.1, we can relate these few observations with high freight rates to a very inelastic supply curve and charterers' willingness to pay.

The lowest rate of a mere 5.586 USD per day was given on a two month contract in the North Sea at the end of 2009. In fact, the three lowest freight rates is separated by less than 200 dollars a day and are all contracts in the North Sea in the latter months of 2009 with durations of less than 2 months. These rates clearly indicate that the end of 2009 was a bad period for ship-owners. Comparing this to the low freight rate level today, Idun Viking was on 31st of January 2015 awarded 5.799 USD/day for a term contract with duration of 49 days. This may indicate that the freight rate level today is similar to the level in 2009. The currently low freight rates are primarily due to excess capacity of vessel available, the oil price drop and Petrobras' corruption scandal. Referring to Dagens Næringsliv (2015), Rem Vision was fixed on a spot contract with Statoil for 7 days and a freight rate of 19.950 NOK or 2.535 USD using the current exchange rate. This is far below the vessels crew- and operational costs. According to Rem Offshores' financial director, they accepted this low freight rate to state an example that the market players will ruin each other if the current market conditions continue.

The average age of ships when they are fixed is exactly 7 years old. Vessels are spread evenly throughout all ages. Some vessels are fixed before they are built. It usually takes around two years to build a vessel for the offshore market. However, 15 observations in our sample are fixed between 3 and 5 years before they are delivered. All of these vessel, except one, are fixed on 8-year contracts with Petrobras working either with drilling support or spill response. It suggests that these vessels are built particularly for this work in close cooperation with the client, Petrobras. Obviously, the number of days forward is extremely high for these vessels as well. Vessel age is also negatively correlated with number of days forward and contract duration, indicating that younger vessels are fixed earlier and on longer contracts than older vessels. Average number of days forward is 3 months, but the median of 21 days indicates that the mean is highly influenced by some new buildings. We can observe that age is negatively correlated with all vessel specifications. In other words, when vessel age increases, vessel specifications such as deck area and BHP decreases. The interpretation of this is that vessels has grown in size and become more modern and able to perform operations in more demanding environments.

Contract durations vary from 10,5 years to the shortest possible term contract of 28 days. The average duration of 610 days is significantly higher than the median, 259, indicating the same thing as above; the average is highly affected by some extremely long contracts while the majority of the contracts lasts less than a year. If we look at the correlation matrix in Table 5.1, it is interesting to see that number of days forward correlates with the duration of the contract. The interpretation of this is that longer contracts are planned more ahead as these are supposed to cover the base needs for services. Contract duration does not seem to be much affected by vessel specifications. However, contract durations are on average much higher in Brazil compared to the North Sea.

Figures in Table 5.3 show that the average contract length in Brazil is close to 4 years while the average duration in the North Sea is just over a year. A positive relationship does also exist between Brazil and number of days forward which is expected when there is a positive relationship between age and region and age and number of days forward.

Table 5.3 Contract Durations

	Brazil	North Sea
Average # of days	1378	384
Average # of years	3,77	1,05
Median # of days	1461	178

Descriptive statistics of vessel specifications shows that vessels vary greatly in size. As expected, the correlation matrix shows a very close relationship between the different vessel specifications. Between them, deck area, DWT and BHP have a high correlation. We expect at least one of the variables to be insignificant after observing the correlation coefficients. There is a minor correlation between vessel specifications and number of days forward suggesting that larger vessels are fixed earlier. A clearer relationship can be seen between vessel specs and the work region. Operations in The North Sea tend to require larger vessels on average compared to Brazil. This might be due to the more demanding weather conditions one can encounter in the region.

The oil price has fluctuated considerably the last decade. The peak was reached in the summer of 2008, just before the financial crisis hit the world economy. Even though the oil price fell dramatically during the recession, it rose back towards the same high levels in the spring of 2011 and 2012 and have stayed above 100 dollars/barrel until September last year. The lowest oil price took place in the beginning of our research period and just after the financial crisis.

The average spot freight rates in the PSV market are slightly higher than the average term freight rates. We find it very interesting to see that the lowest term charter freight rate is almost exactly the same as the lowest monthly average spot freight rate.

6. Analysis and findings

Our findings will be presented and discussed in this chapter. We will start by presenting the regressions results of the model specified in (2). Thereafter we will present a semi-logarithmic model and try to arrive at an optimized model. A similar analysis of the periods 2004-2008 and 2009-2015 will be conducted to investigate any differences in the time periods. A discussion of the findings will be carried out at the end.

6.1 Regression results

Table 6.1 Linear Regression

Source	SS	df	MS		
				N	1187
				F (13, 1173)	79,63
Model	5,376,E+10	13	4,136,E+09	**Prob > F**	0.0000
Residual	6,092,E+10	1173	51932449	**R2**	0,4688
Total	1,147,E+11	1186	9,67,E+07	**Adjusted R2**	0,4629
				Root MSE	7206,4

TC FR	Coefficient	Std. Err	t	P>|t|	[95% Conf. Interval]	
M^2	12,67	2,64	4,79	0,000	7,48	17,86
BHP	0,51	0,14	3,66	0,000	0,24	0,78
DWT	0,22	0,47	0,46	0,646	-0,71	1,14
DP2	1642,15	543,94	3,02	0,003	574,95	2709,35
Age	-125,74	34,39	-3,66	0,000	-193,21	-58,28
Duration	-2,00	0,40	-4,95	0,000	-2,80	-1,21
Days Forward	-0,39	1,24	-0,31	0,754	-2,83	2,05
Production	-7769,25	700,99	-11,08	0,000	-9144,67	-6394,02
Drilling	-6362,41	736,18	-8,64	0,000	-7806,78	-4918,03
Brazil	7711,20	695,42	11,09	0,000	6346,80	9075,60
Oil Price	130,82	9,87	13,25	0,000	111,45	150,20
Monthly Spot	0,27	0,02	16,54	0,000	0,24	0,30
Oil Production	-0,04	0,02	-2,32	0,021	-0,08	-0,01
Constant	16070,73	7688,53	2,09	0,037	985,93	31155,52

Table 6.1 displays the regression results of the model specified in (2). What immediately strikes is the fact that 11 out of 13 variables are significant on a 5% level, which is considerably more than we expected. The R^2 tells us that 46,88% of the variation in the freight rate can be explained by the variables in the model. The two determinants who proved to be insignificant are DWT and number of days forward. This was expected after observing the correlation between DWT and deck area in chapter 5. Also, we were unsure if there would prove to be a significant relationship between the freight rate and Days Forward.

All other vessel specifications are estimated to be significant determinants of the freight rate. The signs of the coefficients are also in line with our assumptions, except Oil Production. The interpretation of the coefficients is that a one unit increase in deck area and BHP will increase the freight rate with 12,67 and 0,5 dollars respectively. The DP2 dummy indicates that vessels with DP2 receive higher freight rates than vessels with DP1 or no DP-class. Freight rates also appear to decrease when the age of the vessel increases.

Contract specifications are estimated to significantly influence the freight rate. As expected, the freight rate decreases when the contract duration increases. The freight rate paid in Brazil is, in this model, estimated to be 7.711 dollars above freight rates paid in The North Sea. Production-and drilling support are estimated to receive 7.769 and 6.362 dollars lower freight rates compared to the average of other scopes of work.

All macro variables included in the model are estimated to be key determinants of the freight rate. A one dollar increase in the oil price is estimated to increase the freight rate by 131 dollars. For every dollar increase in the average monthly spot freight rate, the term freight is estimated to increase by 0,27 dollars. The oil production coefficient tells us that an increase in the worldwide oil production results in lower freight rates. This variable is only statistically significant on a 5% level however.

The coefficient of the constant term indicates that the average reservation freight rate will be 16.071 dollars if all other variables are zero. It indicates the lay-up freight rate level. However it is not possible for all other variables to be zero, e.g. deck area. Also, the constant term is barely significant and has a wide 95% confidence interval.

6.2 Regression diagnostics

To evaluate the validity of the estimated model we will consider some of the assumptions for OLS regression presented in chapter 4.2.

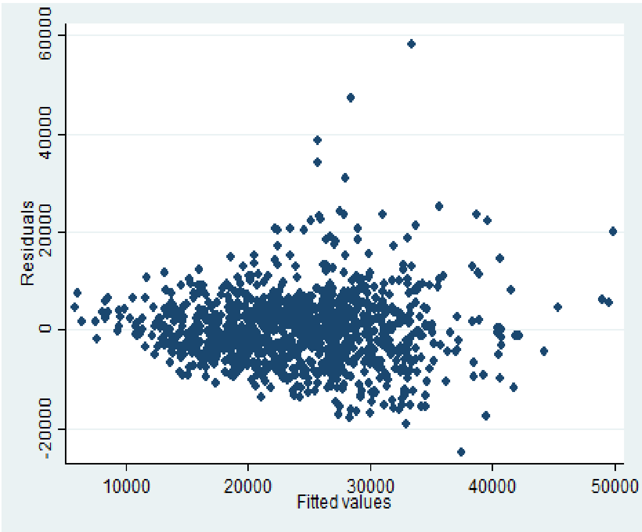
6.2.1 Test for linearity

There should, optimally, be linearity between the dependent variable and the independent variable. After investigating the relationship between the variables closely, all independent variables seem to have close to a linear relationship with the freight rate.

6.2.2 Test for heteroscedasticity

As mentioned, one of the assumptions for regression analysis is homoscedasticity. Residuals can therefore not be heteroscedastic. Identification of heteroscedasticity can be observed graphically. This may be carried out by plotting the residuals against the fitted values. A pattern in the spread, e.q. in the shape of a cloud of dots becoming wider or narrower when the fitted values increase, indicates unwanted heteroscedasticity. The figure below shows signs of unwanted heteroscedasticity. It seems that the model have difficulties trying to estimate high freight rates. Some of the large residuals may not be explained by the variables included in the model due to the inelastic shape of the supply curve when freight rates are high.

Figure 6.1 Linear Regression - Residual versus Fitted Plot



6.2.3 Test for autocorrelation

When using time series in regression analysis autocorrelation may be a problem. To test for the presence of first-order autocorrelation, we used the Durbin-Watson test.

$$d = \frac{\sum_{t=2}^{T}(e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^2}$$

Table 6.2 Linear Regression - Durbin-Watson Test

Durbin-Watson test	
Sum of Squared Difference of Residuals	1,06031E+11
Sum of Squared Residuals	60882169339
Durbin-Watson D-value	**1,742**

The d-values always lie between 0 and 4. A d-value substantially less than 2 indicates evidence of positive autocorrelation. Conversely, a d-value substantially higher than 2 shows evidence of negative autocorrelation. The rule of thumb, when using a Durbin-Watson test, is that there exist no autocorrelation if the d-value is between 1,5 and 2,5. Our model has a d-value of 1,742, indicating close to zero autocorrelation.

6.2.4 Test for multicollinearity

Linear regression assumes no or little multicollinearity in the data. Multicollinearity may occur when the independent variables are not independent from each other. In order to test for multicollinearity, we performed a variance inflation factor (VIF) test. It tells us to what degree the independent variable correlates with the other independent variables. The variables should not have a VIF-score greater than 10 and the 1/VIF should not be lower than 0,05. If some variables deviate from this they should be considered removed from the regression model.

Table 6.3 Variance Inflation Factor Test

Variable	VIF	1/VIF
M^2	5,04	0,19841
DWT	4,66	0,21459
Production	2,79	0,35842
Drilling	2,78	0,35971
BHP	2,36	0,42373
Duration	2,00	0,50000
South America	1,94	0,51546
Oil Production	1,64	0,60976
Days Forward	1,56	0,64103
Age	1,54	0,64935
DP2	1,53	0,65359
Oil Price	1,4	0,71429
Monthly Spot	1,25	0,80000
Mean VIF	2,35	

The VIF test above suggests that multicollinearity may be present when both DWT and M^2 are included. This is in accordance with our expectations after observing the correlation matrix and regression results. All other independent variables have satisfying levels of multicollinearity.

6.2.5 Test for normal distributed residuals

Figure 6.2 Linear Regression - Residual Normality Plot

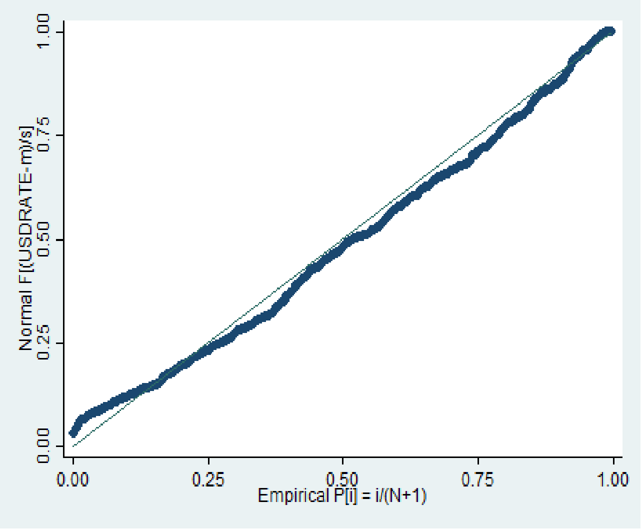


Figure 6.2 illustrates a normal probability plot for the linear model. A plot like this attempts to tell us to what degree the residuals are normally distributed. If the residuals are perfectly normal distributed they will follow the linear line and thereby not have any deviations between predicted and actual values. The probability of over- and underestimating a value should be fairly the same in a good model. As we can see from the plot above, the residuals does not appear to be perfectly normal distributed seeing that they do not follow the line perfectly. Despite this one can say that the residuals do not appear to create any major issues for the model and findings.

6.3 Semi-logarithmic model

After considering the regression results and assumption tests we propose a semi-logarithmic model to examine the freight rate elasticity:

$$\mathbf{LogFR}_{i,t} = \beta_0 + \beta_1 \mathbf{M}^2_i + \beta_2 \mathbf{BHP}_i + \beta_3 \mathbf{DP2}_i - \beta_4 \mathbf{AGE}_i - \beta_5 \mathbf{DURATION}_i - \beta_6 \mathbf{PROD}_i - \beta_7 \mathbf{DRILL}_i + \beta_8 \mathbf{BRAZIL}_i + \beta_9 \mathbf{OILP}_i + \beta_{10} \mathbf{SPOT}_i + \beta_{11} \mathbf{WORLDOILP}_i \quad \mathbf{(3)}$$

We transform the original linear model to semi-logarithmic as the interpretation of the coefficients improves. Coefficients do now show relative changes in the freight rate. This provides an improved and more logical interpretation of the determinants. Regression results from the semi-logarithmic model are presented in Table 6.4. R^2 has increased from the previous model to 0,50 indicating that the model is slightly better at explaining the variation in the freight rate. A one unit increase in the vessel properties deck area, BHP and DWT are estimated to increase the freight rate by 0,055%, 0,002% and 0,001% respectively. DWT is insignificant in this model as well. Whether a vessel has DP2 or not is estimated to influence the freight rate by 6,36%. A one year increase in vessel age is estimated to lower the freight rate by 0,6%. If the contract duration increases by one day, the estimated effect on the freight rate is a 0,006% reduction. Number of days forward is still found to be insignificant and has very little effect on the freight rate. Both production- and drilling support are estimated to produce lower freight rates compared to other scopes of work. Conversely, freight rates in Brazil are estimated to be 30,5% higher compared to the North Sea. If the oil price were to increase by one dollar, the freight rate is estimated to increase by 0,65%. A one dollar increase in the average monthly spot freight rate is predicted to increase the term freight rate by 0,001%.

Table 6.4 Semi-logarithmic Regression

Source	SS	df	MS		
				N	1187
				F (13, 1173)	90,23
Model	100,592	13	7,738	**Prob > F**	0.0000
Residual	100,588	1173	0,086	**R2**	0,50
Total	201,180	1186	0,170	**Adjusted R2**	0,4945
				Root MSE	0,29284

TC FR	Coefficient	Std. Err	t	P>|t|	[95% Conf. Interval]	
M^2	0,00055	0,0001	5,09	0,000	0,0003	0,0008
BHP	0,00002	5,63E-06	3,41	0,001	8,17E-06	3,03E-05
DWT	0,00001	1,91E-05	0,68	0,498	-2,46E-05	0,0001
DP2	0,06363	0,0221	2,88	0,004	0,0203	0,1070
Age	-0,00603	0,0014	-4,32	0,000	-0,0088	-0,0033
Duration	-0,00006	1,34E-05	-3,70	0,000	-0,0001	-2,8600E-05
Days Forward	-9,06E-06	0,0001	-0,18	0,858	-0,0001	0,0001
Production	-0,28654	0,0285	-10,06	0,000	-0,3424	-0,2307
Drilling	-0,22242	0,0299	-7,44	0,000	-0,2811	-0,1637
Brazil	0,30484	0,0283	10,79	0,000	0,2494	0,3603
Oil Price	0,00647	0,0004	16,12	0,000	0,0057	0,0073
Monthly Spot	0,00001	6,65E-07	16,32	0,000	9,55E-06	1,22E-05
Oil Production	-1,6E-06	7,86E-07	-1,97	0,049	-3,09E-06	4,00E-09
Constant	9,41150	0,3124	30,12	0,000	8,7985	10,0245

Model assumption tests can be found in the appendices. After changing to the semi-logarithmic model, the d-value in the Durbin-Watson test drops to 1,554. Although the d-value is lower in the semi-logarithmic model, the d-values is still within the rule of thumb range, signifying close to no existence of autocorrelation.

The plot of the residuals shows no sign of heteroscedasticity. The VIF test produce the same results as the linear model since the independent variables have not changed. The plot for normal distributed residuals below has the same interpretation as in the linear model.

All in all the semi-logarithmic model seem to provide a better fit and interpretation of our data. We will continue to use this specification of the model in the remaining parts of our analysis.

6.4 Model optimization

In Table 6.5 we have excluded one variable at a time. We always exclude the most insignificant or least significant variable. Therefore, we started by excluding Days Forward from the semi-logarithmic model.

From the results in column [2] we observe no change in R^2. We also see that the exclusion has had limited effect on the remaining coefficients. Following this we removed DWT, the only insignificant variable from [2]. The elimination of DWT led to relatively small changes in the remaining coefficient's values. However, Oil Production is no longer significant on a 5% level, and led to the removal of the variable. The freight rate determination model has been optimized in [4] when all variables are significant on a 1% level All variables in regression [4] are statistically significant on a 1% level, and both the coefficients and R^2 is approximately the same as in the original semi-logarithmic model. The optimized model consists of 10 vessel-, contract- and macro specific variables and is able to explain near half of the variation in the PSV term charter freight rates the past 11 years.

Table 6.5 Model Optimization Regression 1-4

Variables	[1] TC FR	[2] TC FR	[3] TC FR	[4] TC FR
M^2	0.000547***	0.000546***	0.000601***	0.000594***
	(5.092)	(5.092)	(8.403)	(8.314)
BHP	1.92e-05***	1.91e-05***	1.98e-05***	1.85e-05***
	(3.412)	(3.414)	(3.593)	(3.383)
DWT	1.29e-05	1.29e-05		
	(0.677)	(0.678)		
DP2	0.0636***	0.0639***	0.0628***	0.0602***
	(2.879)	(2.902)	(2.859)	(2.744)
Age	-0.00603***	-0.00599***	-0.00617***	-0.00636***
	(-4.318)	(-4.346)	(-4.559)	(-4.706)
Duration	-6.08e-05***	-6.21e-05***	-6.22e-05***	-5.99e-05***
	(-3.702)	(-4.195)	(-4.202)	(-4.054)
Days Forward	-9.06e-06			
	(-0.180)			
Production	-0.287***	-0.286***	-0.284***	-0.287***
	(-10.06)	(-10.20)	(-10.18)	(-10.27)
Drilling	-0.222***	-0.222***	-0.220***	-0.223***
	(-7.435)	(-7.456)	(-7.427)	(-7.541)
Brazil	0.305***	0.305***	0.305***	0.299***
	(10.79)	(10.79)	(10.80)	(10.65)
Oil Price	0.00647***	0.00647***	0.00646***	0.00611***
	(16.12)	(16.14)	(16.13)	(17.12)
Monthly Spot	1.09e-05***	1.08e-05***	1.09e-05***	1.13e-05***
	(16.32)	(16.42)	(16.47)	(18.19)
Oil Production	-1.55e-06**	-1.55e-06**	-1.53e-06*	
	(-1.967)	(-1.974)	(-1.952)	
Constant	9.411***	9.414***	9.409***	8.812***
	(30.12)	(30.17)	(30.16)	(138.9)
Observations	1,187	1,187	1,187	1,187
R-squared	**0.500**	**0.500**	**0.500**	**0.498**
t-statistics in parentheses				
*** p<0.01, ** p<0.05, * p<0.1				

Curious to see the effect each variable has on the freight rate we continued to remove variables from the model. The regression results can be found in Appendix 3.1. Worth-mentioning results from this process is that M^2, Brazil, Oil Price and Monthly Spot alone explains 41,4% of the variation in the term charter freight rate. We find it interesting that these 4 variables, from all defined determination categories, explains the variation in the freight rate to such an extent.

6.5 Time period analysis

Figure 3.3 and Figure 3.4 drew our attention to the intersection between average spot- and term freight rates observed in the year-end 2008/2009. It made us want to examine if freight rate determinants have changed during our analysis period. A stepwise regression is performed where variables are excluded by their level of significance. The regression results can be found in the appendices. 434 observations are analyzed from 2004-2008 and 753 observations from 2009-2015. Table 6.6 displays the optimized models for all periods where all variables are significant on a 1% level.

The quite high R^2 of 0,62 for the first period could be explained by the number of observations. However, we interpret it to be due to the differences in data variation between the two periods examined. The coefficient of variance (standard deviations/mean) in the descriptive statistics in the appendices shows greater variations in the first period for all variables except Oil Production. Also, referring to Figure 3.6, the variations in the spot- and term charter freight rates were greater in the backwardated market from 2004-2008 compared to the contango-market in the latter period.

Worth-mentioning findings from the first are that the contract duration is one of the most significant variables along with the monthly worldwide oil production. The findings in the latter period appear to be quite similar to the entire period. A more thorough discussion will follow in the next chapter.

Table 6.6 Optimization Comparison

Variables	2004-2015 TC FR	2004-2008 TC FR	2009-20015 TC FR
M^2	0.000594***	0.000786***	0.000443***
	(8.314)	(8.548)	(5.656)
BHP	1.85e-05***		3.78e-05***
	(3.383)		(6.432)
DWT			
DP2	0.0602***		0.0898***
	(2.744)		(4.086)
Age	-0.00636***	-0.00925***	
	(-4.706)	(-4.913)	
Duration	-5.99e-05***	-0.000186***	
	(-4.054)	(-7.641)	
Days Forward		-0.000299***	
		(-3.254)	
Production	-0.287***	-0.356***	-0.235***
	(-10.27)	(-8.141)	(-7.336)
Drilling	-0.223***	-0.346***	-0.175***
	(-7.541)	(-7.171)	(-5.306)
Brazil	0.299***		0.336***
	(10.65)		(14.92)
Oil Price	0.00611***	0.00382***	0.00557***
	(17.12)	(3.874)	(11.47)
Monthly Spot	1.13e-05***	9.96e-06***	1.24e-05***
	(18.19)	(9.349)	(10.61)
Oil Production		2.32e-05***	-2.58e-06***
		(4.316)	(-3.399)
Constant	8.812***	-0.109	9.751***
	(138.9)	(-0.0519)	(31.05)
Observations	1,187	434	753
R-squared	**0.498**	**0.620**	**0.530**

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6.6 Findings discussion

We find it very interesting and satisfying to see that our model expectations fit well with the regression outcome. Most variables are found to be significant determinants of the freight rate on a 5% level. Every variable besides Oil Production influence the freight rate in the projected way. However, the variable is not significant when the whole period is optimized, and has a positive sign in the optimized model from 2004-2008 and negative sign in the following period.

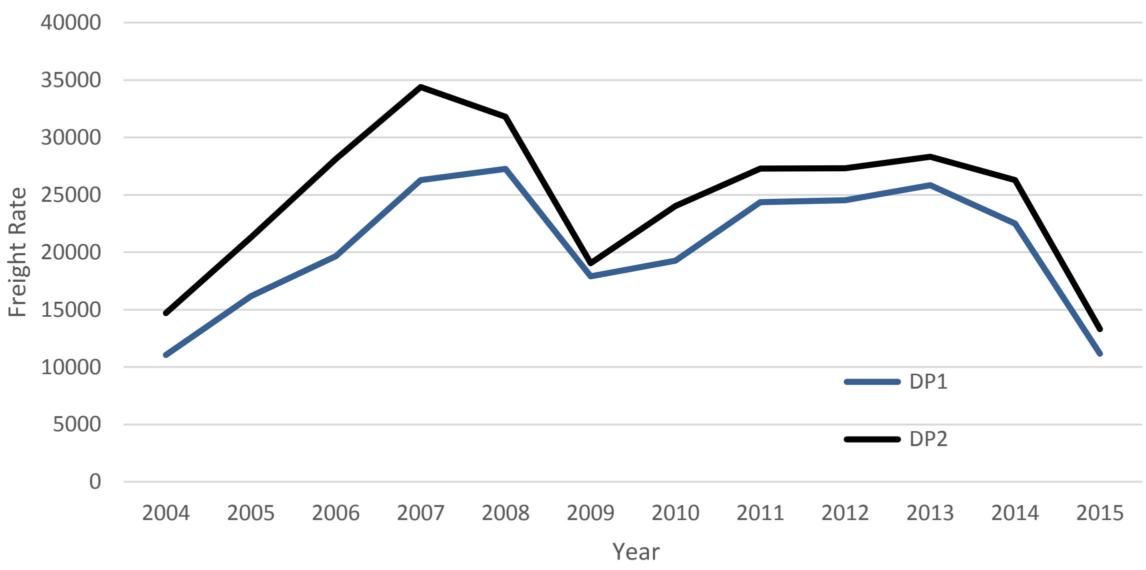
First of all, the analysis finds there to be no relationship between number of days forward and the freight rate when the whole period is analyzed. This was the variable we were the most unsecure of, but we were eager to test due to the findings in Alizadeh and Talley (2011b). Though, it did show a positive correlation with contract duration in our data and is significant on a 1% level in the first period. The sign of the coefficient indicates that increased number of days forward leads to lower freight rates. This is opposite of what Alizadeh and Talley (2011b) find for the tanker market.

DWT is also found to not be a significant determinant of the freight rate in any of our regressions. This is all in all due to its correlation with deck area. DWT would have proven to be a significant determinant if deck area was excluded from the model. This was found when experimenting and working with the data, but is not presented in the thesis. M^2 is found to be the best and most logical determinant of the two.

Deck area, M^2, is found to be a significant determinant of the freight rate in all of our analyses. It is one of the three remaining variables in our model optimization attempt, see Appendix 3.1. The positive relationship between deck area and the freight rate is in accordance with our hypothesis that a vessel with larger deck area receive higher freight rate. All in all it is found to be the most important vessel specification. BHP is found to be significant in both the linear and the original semi-logarithmic regression analysis along with the DP2 dummy. Increasing engine size and DP-class have the anticipated effect on the freight rate. Of the two, only DP2 is significant on a 10% level from 2004-2008. Both variables are significant from 2009-2015 on a 1% level. Figure 6.3 shows that freight rates for vessels with DP2 has been consistently higher compared to freight rates for vessels without DP2. In accordance with our hypothesis, charterers value DP2 higher and are willing to pay for the quality it brings. In low freight rate environments the difference in the freight rate is reduced however. The reduced difference can be explained by supply and demand balance in the market at the time. When capacity is scarce, charterers will outbid each other to charter higher quality vessels and freight rate differences arise between DP-classes. When there is excess capacity and low freight rates, a charterer is likely to choose a vessel with DP2 first when the difference in costs between a DP1 and DP2 is minimal. In other words, the DP2 “premium” diminishes in a market trough.

Dummy variables for scope of work appear to be key determinants of the freight rate. Both production- and drilling support achieve significantly lower freight rates than other scopes of work. This is true for all time periods investigated and in accordance with our expectations. We consider it to be due to the predictable and standardized nature of these scopes of work.

Figure 6.3 DP-class' Average Freight Rate

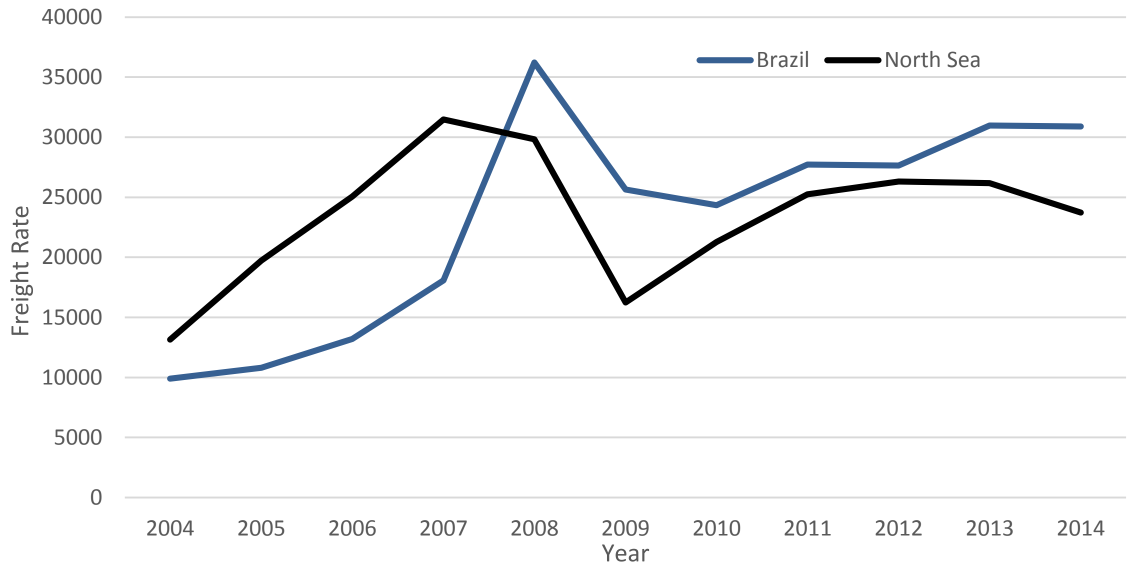


Increasing vessel age is estimated to result in lower freight rates in all of our analyzes, in line with expectations. The same can be interpreted about contract duration. Vessels on longer contracts appear to achieve lower freight rates. At first, it surprised us is that contract duration is one of the most significant determinants in the period from 2004-2008 while being insignificant in the following period. However, some explanations to this seem logical. In the latter period, by observing the thick order book and excess supply of vessels, charterers may have chosen to fix vessels on shorter contracts as they were convinced that they will always be able to charter a vessel cheaply. Charterers would not need to charter vessels on long-term contracts in this scenario unless they are eager to fix a specific vessel. Also, a high correlation between Brazil and contract duration is present in the most recent period and makes it difficult for both variables to be significant. We experimented with the data and found contract duration to be significant on a 1% level when all variables except the Brazil dummy was included in the model.

The dummy variable for where the scope of work is taking place proves to be a very significant determinant of the freight rate. The dummy variable is insignificant in the period 2004-2008 but is one of the most significant variables from 2009-2015. The explanation for this is the same as above; the correlation between the Brazil dummy and contract duration makes it difficult for both variables to be significant at the same time. When experimenting with the data, the Brazil dummy is found to be negative and significant on a 1% level in the first period when all variables except contract duration is included in the model. However, contract duration appears to be the best determinant of the two from 2004-2008 and Brazil appears to be best from 2009-2015.

The significance of the region variable proves our assumption that there are differences in freight rates between the regions. We believe the main reason for this to be the fact that costs related to operations in Brazil have increased dramatically in the recent period. Figure 6.4 displays the yearly average term charter freight rates in the North Sea and Brazil. Compared to the North Sea, freight rates in Brazil were significantly lower before the costs started rising but have been higher from 2008 until today.

Figure 6.4 Regions' Yearly Average Term Charter Freight Rates



As expected, the oil price is found to be the most important determinant of the freight rate when analyzing the whole period. It is the most significant variable in all regression analyses except in the time period 2004-2008, due to the already explained correlation with Oil Production. Increased oil price will in general imply increased freight rates. The worldwide oil production has an opposite pattern. It is among the least significant determinants in all regressions except the first period where it is the most significant variable.

The monthly average spot freight rate is consistently one of the most significant variables in our analyses. The spot has been a leading variable throughout the whole examination period.

The correlation matrix and descriptive statistics found in the appendices show interesting facts about the periods. The spot freight rate has a correlation of 0,44 with the term charter freight rate from 2004-2008 and 0,35 from 2009-2015. This is opposite of what we expected. The higher correlation in the former period might imply that the spot- and term charter freight rates were more interrelated before the financial crisis. Monthly average spot freight rates were 36.534 USD/day in the first period and 17.490 USD/day in the last period, while the monthly average term charter freight rates were 24.413 USD/day and 24.195 USD/day, respectively. It indicates that the spot market has weakened while the term market has remained at the same freight rate level. These findings appear to be in line with Figure 3.2. When the market is peaking, spot freight rates are substantially higher than term freight rates. The opposite appears to be true during a trough. In addition, the variation in spot freight rates is high in a high freight rate environment and low during a lay-up freight rate environment. The standard deviations in Figure 3.6 display this well, especially when having the freight rates in Figure 3.4 in mind. Figure 3.3 captures the underlying trends in Figure 3.4.

7. Criticism and further research

Some limitations and drawback exist to our findings. Some of the limitations within our thesis lie in the chosen methodology. An OLS regression may not be the optimal way to analyze the data as there might not be a perfect linear relationship between all determinants and the freight rate. However, the estimation technique provides quite good results and thereby we did not use a more sophisticated approach.

Much of the limitations lies within the data sample. A concern is that there probably exists a large amount of contracts not reported in the data which could indicate that results are not as representative as they could be. Yet, we see this as a data limitation problem we cannot influence.

The sample is also a non-consistent time series as there are gaps in the time series with no observations. This might be due to lack of reported contracts but is also likely to be because PSV term contracts are not fixed on a daily basis. Also, the mentioned freight rate emittances in our sample may create disturbing results although these are spread out consistently through the sample. A limitation is also present due to our time consuming effort to manually obtain parts of the data.

The original and unique data consists of fixtures in spot- and term market for both PSVs and AHTS'. A possibility for further PSV research could be to examine the spot charter freight rate determination and compare it to the findings in this thesis. Similar research can also be conducted for AHTS vessels. It would be interesting to compare the spot- and term charter freight rate determination across vessel types to reveal which similarities and differences exist between the markets. We hope that this thesis and our data will encourage others to examine the offshore markets further.

8. Concluding remarks

The aim of this thesis has been to investigate the determinants of PSV term charter freight rates. Relevant determinants have been identified to analyze the freight rate. Determinants can be separated into vessel specific, contract specific and macro variables. The period examined spans from January 2004 to March of 2015. We have also analyzed the period before and after 2009 to investigate whether the determination of term charter freight rates changed after the financial crisis.

The investigation reveals several important findings. Most variables in the model are found to be significant determinants of the freight rate on a 5% significance level. The freight rates are found to be determined by a combination of vessel-, contract- and macro specific variables at the fixture date. Particularly, the vessel's deck area and operating region, the oil price and the monthly average spot freight rate are found to be the most significant determinants when the whole period is analyzed. All of these findings are in line with our hypotheses and may be of great value to all market participants. Vessel size and quality have increased during the last decades. Larger deck area and BHP implies economies of scale for both the charterer and the ship-owner. Chartering an older vessel costs less for the charterer, but increases the likelihood of reduced vessel quality. Dynamic Positioning level 2 is considered to be a mark of quality and is compensated for. A negative relationship between contract duration and the freight rate is in line with the term structure theory. In fact, contract duration stands out as one the most significant determinants from 2004-2008. No significant relationship is found between the length of the period from fixture- to start date and the freight rate. Production- and drilling support achieve significantly lower freight rates compared to all other scopes of work. Freight rate levels are found to be significantly higher in Brazil compared to the North Sea, especially after the financial crisis. All in all, and in accordance with the hypothesis, the oil price and the spot freight rates appears to be the most significant determinants of the term charter freight rates.

The term structure findings appear to comply well with the existing literature and theories. Referring to Figure 3.4, Zannetos' (1966) theory appears to match to the relationship between spot- and term charter freight rates in the PSV market: volatile spot freight rates and term charter freight rates which moves in the same direction with less volatility.

The PSV freight rates term structure can be modelled in accordance with Strandenes' (1984) term structure model. When the market is in contango, spot freight rates are rather low and the term charter freight rates are greater. Conversely, when the market is backwardated, the spot freight rates are much higher than the current term charter freight rates. In addition, the volatility of the freight rates are low during a trough and high during a peak.

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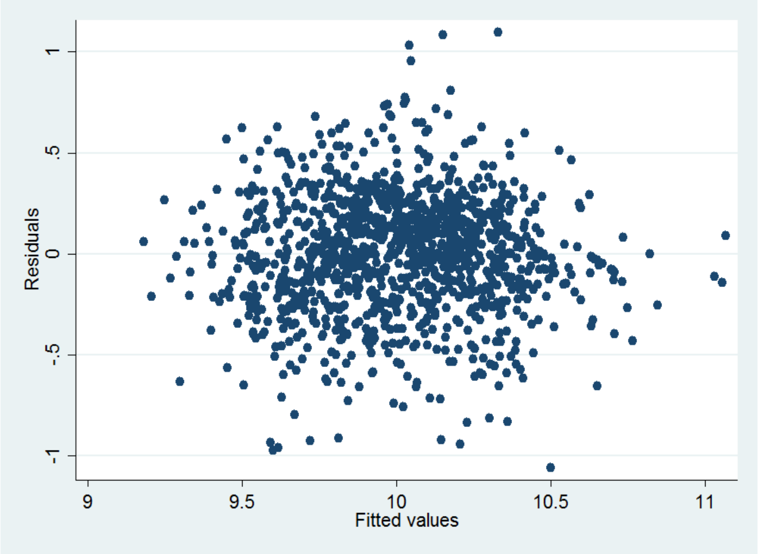
NB (2015) http://www.norges-bank.no/WebDAV/stat/valutakurser/xlsx/valutakurser_m.xlsx *Obtained 15.04.2015*

Appendices

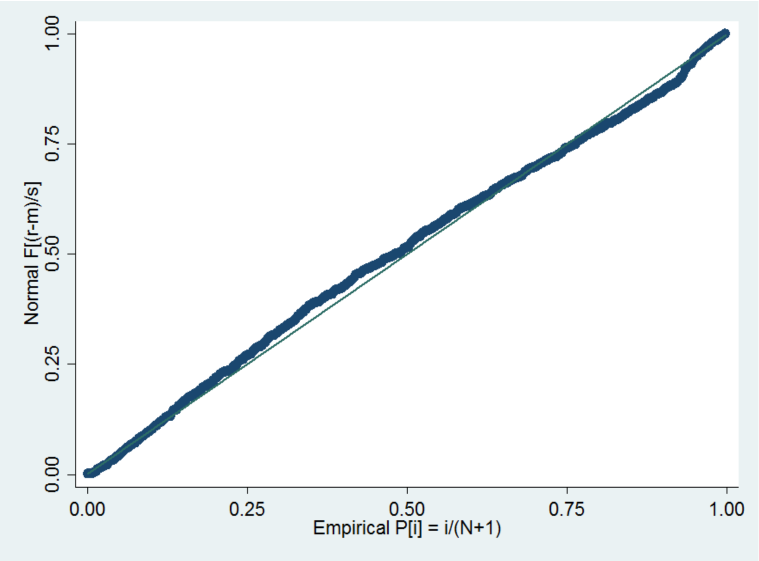
Appendix 1.1 Raw Data Example

Contract Status	Vessel Name	Manager	Vessel Type	Contract	Activity	Region	Country	Client	Fixture Date	Start Date	End Date w/o (	Duration	Rate	USD Rate
Completed	A.H. Portofino	Finarge	AHTS	Term	Production Suppor	South Ameri	Brazil	Petrobras	1 aug 2004	6 aug 2004	28 mai 2007	1 025	USD 9,25	9 255
Completed	A.H. San Frutt	Viking Supply Ships	AHTS	Term	Production Suppor	Northwest E	United Kingdo	OMC	19 jul 2004	24 jul 2004	5 sep 2004	43	GBP 4,75	8 899
Completed	Acadian Sea	Secunda Marine	PSV	Term	Drilling Support	Northwest E	United Kingdo	Total	22 des 2005	10 jan 2006	1 apr 2006	81		
Completed	Acadian Sea	Secunda Marine	PSV	Term	Drilling Support	Northwest E	United Kingdo	Talisman	20 feb 2006	1 apr 2006	1 apr 2007	365	GBP 9,50	16 579
Completed	Acadian Sea	Secunda Marine	PSV	Term	Production Suppor	Northwest E	United Kingdo	Talisman	27 mar 2007	1 apr 2007	1 mai 2009	761	GBP 9,80	19 236
Completed	Amy Candies	Otto Candies	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	11 jul 2007	15 jul 2007	14 jul 2009	730	USD 16,8	16 800
Completed	Aquarius	Gulf Offshore	PSV	Term	Production Suppor	Northwest E	United Kingdo	BP	1 nov 2004	15 nov 2004	15 nov 2005	365	GBP 6,90	12 644
Completed	Aquarius	Gulf Offshore	PSV	Term	Drilling Support	Northwest E	United Kingdo	ADTI	1 des 2005	5 des 2005	20 feb 2006	77	GBP 13,0	22 477
Completed	Aries Swan	Aries Offshore	PSV	Term	Production Suppor	Northwest E	Norway	ConocoPhillips	15 mai 2007	26 mai 2007	26 nov 2007	184	GBP 18,0	35 674
Completed	Asso 23 (VEN	Augusta Offshore	AHTS	Term	Drilling Support	South Ameri	Brazil	Petrobras	22 okt 2004	22 okt 2004	22 mai 2005	212	USD 16,1	16 100
Completed	Asso 23 (VEN	Augusta Offshore	AHTS	Term	Drilling Support	South Ameri	Brazil	Petrobras	22 mar 2007	22 mar 2007	22 mar 2011	1 461	USD 22,8	22 814
Completed	Asso 26 (VEN	Augusta Offshore	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	3 jun 2005	4 jan 2006	8 mar 2014	2 985	USD 13,5	13 523
Completed	Asso 27 (VEN	Augusta Offshore	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	1 okt 2006	5 mai 2007	30 jun 2010	1 152		
Completed	Astro Arraia	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	8 des 2005	8 des 2005	22 nov 2010	1 810	USD 10,0	10 098
Completed	Astro Badejo	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	27 sep 2005	27 sep 2005	12 jul 2010	1 749	USD 10,0	10 098
Completed	Astro Dourado	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	15 apr 2006	15 apr 2006	27 jun 2007	438	USD 7,33	7 332
Completed	Astro Enchova	Astromaritima	PSV	Term	Drilling Support	South Ameri	Brazil	Petrobras	3 apr 2005	27 mai 2005	10 jun 2010	1 840	USD 10,3	10 367
Completed	Astro Garoupa	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	23 feb 2006	23 feb 2006	1 feb 2011	1 804	USD 10,0	10 098
Completed	Astro Guaricen	Astromaritima	AHTS	Term	Production Suppor	South Ameri	Brazil	Petrobras	12 apr 2005	12 apr 2005	29 mai 2010	1 873	USD 10,3	10 367
Completed	Astro Parati	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	25 mai 2006	25 mai 2006	2 jan 2011	1 683	USD 10,0	10 098
Completed	Astro Ubarana	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	26 jun 2004	26 jun 2004	9 okt 2007	1 200	USD 10,3	10 300
Completed	Astro Vermelh	Astromaritima	PSV	Term	Production Suppor	South Ameri	Brazil	Petrobras	30 jan 2004	30 jan 2004	8 nov 2008	1 744	USD 10,3	10 367
Completed	Atrek	Specialist Marine S	AHTS	Term	Drilling Support	South Ameri	Brazil	Petrobras	10 mar 2005	21 mai 2005	1 aug 2007	802	USD 10,3	10 351
Completed	Atrek	Chernomorneftegaz	AHTS	Term	Drilling Support	South Ameri	Brazil	Petrobras	1 aug 2007	1 aug 2007	13 jul 2010	1 077	USD 14,3	14 351
Completed	Balder Viking	Viking Supply Ships	AHTS	Term	Production Suppor	Northwest E	Norway	ExxonMobil	20 des 2004	20 des 2004	20 jan 2005	31	GBP 15,0	29 219
Completed	Beta	Bukser og Berging	AHTS	Term	Standby	Northwest E	Norway	NCD	24 aug 2005	1 okt 2005	30 mar 2006	180		
Completed	Beta	Bukser og Berging	AHTS	Term	Construction Supp	Northwest E	Norway	Statoil	3 apr 2007	9 mai 2007	17 aug 2007	100	NOK 200,	32 840
Completed	Blizzard	ITC	AHTS	Term	Construction Supp	Northwest E	United Kingdo	Saipem	22 mar 2007	15 apr 2007	20 jul 2007	96	GBP 18,0	35 302
Completed	Boa Fortune	Taubatkompaniet A	PSV	Term	Drilling Support	Northwest E	Denmark, Nor	Altinex	20 mar 2007	26 mar 2007	5 mai 2007	40	GBP 25,0	48 575
Completed	Boa Fortune	Taubatkompaniet A	PSV	Term	Drilling Support	Northwest E	Denmark, Nor	DONG	29 mar 2007	5 mai 2007	1 aug 2007	88	GBP 25,0	49 113
Completed	Boa Fortune	Taubatkompaniet A	PSV	Term	Drilling Support	Northwest E	Netherlands	Peterson	16 jul 2007	1 aug 2007	1 jan 2008	153	GBP 17,5	35 600
Completed	Boa Fortune	Taubatkompaniet A	PSV	Term	Production Suppor	Northwest E	Netherlands	Peterson	19 des 2007	1 jan 2008	7 apr 2008	97	GBP 15,0	30 270
Completed	BOS Turquesa	Farstad	AHTS	Term	Production Suppor	South Ameri	Brazil	Petrobras	14 feb 2007	14 feb 2007	10 feb 2015	2 918	USD 25,2	25 243
Completed	Boulder	ITC	AHTS	Term	Construction Supp	Northwest E	United Kingdo	Saipem	22 mar 2007	15 apr 2007	20 jul 2007	96	GBP 18,0	35 302

Appendix 2.1 Semi-logarithmic - Residual versus Fitted Plot



Appendix 2.2 Semi-logarithmic - Residual Normality Plot



Appendix 2.3 Semi-logarithmic - Durbin-Watson Test

Durbin-Watson test	
Sum of Squared Difference of Residuals	156,151
Sum of Squared Residuals	100,456
Durbin-Watson D-value	**1,554**

Appendix 3.1 Model Optimization Regression 5-11

Variables	[5] TC FR	[6] TC FR	[7] TC FR	[8] TC FR	[9] TC FR	[10] TC FR	[11] TC FR
M^2	0.000621***	0.000792***	0.000775***	0.000856***	0.000828***	0.000831***	0.000619***
	(8.749)	(14.52)	(14.16)	(15.76)	(14.97)	(14.70)	(11.41)
BHP	2.04e-05***						
	(3.739)						
DWT							
DP2							
Age	-0.00791***	-0.00880***	-0.00780***				
	(-6.416)	(-7.242)	(-6.512)				
Duration	-6.40e-05***	-5.95e-05***					
	(-4.339)	(-4.031)					
Days Forward							
Production	-0.295***	-0.300***	-0.309***	-0.293***	-0.134***		
	(-10.61)	(-10.72)	(-10.99)	(-10.29)	(-7.314)		
Drilling	-0.232***	-0.243***	-0.245***	-0.215***			
	(-7.846)	(-8.200)	(-8.230)	(-7.191)			
Brazil	0.299***	0.285***	0.220***	0.227***	0.214***	0.238***	
	(10.62)	(10.16)	(9.517)	(9.632)	(8.937)	(9.798)	
Oil Price	0.00619***	0.00619***	0.00627***	0.00630***	0.00634***	0.00657***	0.00736***
	(17.37)	(17.28)	(17.42)	(17.20)	(16.94)	(17.25)	(19.01)
Monthly Spot	1.12e-05***	1.11e-05***	1.09e-05***	1.08e-05***	1.11e-05***	1.13e-05***	1.01e-05***
	(18.02)	(17.76)	(17.36)	(16.92)	(17.18)	(17.13)	(15.00)
Oil Production							
Constant	8.833***	8.861***	8.850***	8.711***	8.565***	8.460***	8.646***
	(139.8)	(140.5)	(139.5)	(143.4)	(146.5)	(146.1)	(152.0)
Observations	1,187	1,187	1,187	1,187	1,187	1,187	1,187
R-squared	**0.495**	**0.489**	**0.482**	**0.463**	**0.440**	**0.414**	**0.367**

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 4.1 2004-2008 - Correlation Matrix

	TC FR	M^2	BHP	DWT	DP2	Age	Duration	Days Forward	Production	Drilling	Brazil	Oil Price	Monthly Spot	Oil Production
TC FR	**1**													
M^2	0,39	**1**												
BHP	0,27	0,68	**1**											
DWT	0,34	0,84	0,65	**1**										
DP2	0,33	0,39	0,42	0,38	**1**									
Age	-0,21	-0,26	-0,31	-0,36	-0,48	**1**								
Duration	-0,30	-0,06	0,02	-0,07	-0,01	-0,08	**1**							
Days Forward	0,05	0,28	0,31	0,30	0,13	-0,21	0,30	**1**						
Production	-0,20	0,03	0,03	0,00	-0,05	0,05	0,20	-0,04	**1**					
Drilling	-0,04	-0,06	-0,11	0,02	-0,03	-0,11	-0,17	-0,09	-0,72	**1**				
Brazil	-0,26	-0,37	-0,30	-0,35	-0,17	0,16	0,28	-0,05	0,07	-0,09	**1**			
Oil Price	0,48	0,07	0,00	0,07	0,13	-0,09	0,03	0,06	-0,01	-0,07	-0,02	**1**		
Monthly Spot	0,44	0,07	0,06	0,09	0,07	-0,02	0,00	0,16	-0,09	-0,01	-0,10	0,29	**1**	
Oil Production	0,48	0,16	0,07	0,17	0,17	-0,09	0,01	0,10	0,05	-0,09	-0,08	0,78	0,23	**1**

Appendix 4.2 2004-2008 - Descriptive Statistics

Stats	TC FR	M^2	BHP	DWT	Age	Duration	Days Forward	Oil Price	Monthly Spot	Oil Production
Mean	24413	769	7020	3717	8	520	84	69	36534	402797
Median	20988	750	6600	3570	5	246	18	62	34457	401872
Max	91667	1220	15791	7620	32	3836	1526	133	73482	414802
Min	7017	200	2400	951	-3	30	0	31	6997	386605
SD	12554	173	2249	901	8	650	181	24	14487	4371
SD / Mean	602,00	8,32	107,93	43,27	0,40	32,20	8,70	1,16	695,41	209,80
Skewness	1,35	-0,42	0,99	-0,12	1,09	2,21	3,82	1,10	0,37	0,28
Kurtosis	5,52	2,89	3,90	4,18	3,29	8,24	20,35	3,59	2,49	2,33

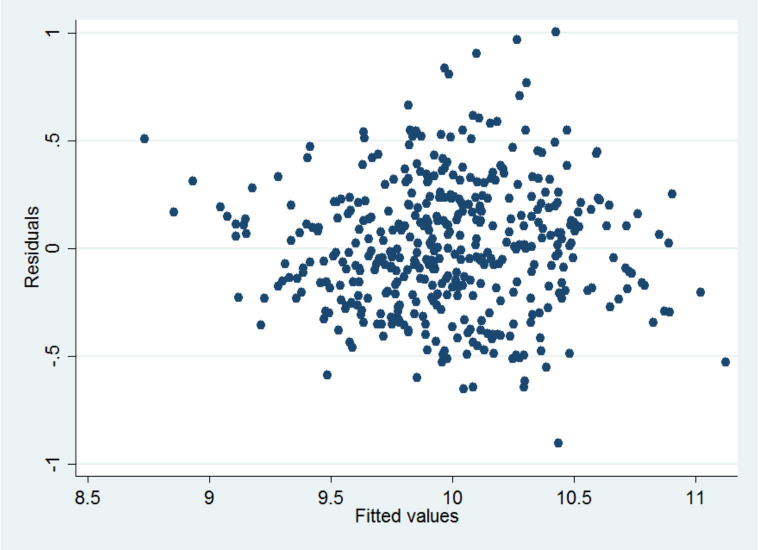
Appendix 4.3 2004-2008 - Regression 1-12

Variables	[1] TC FR	[2] TC FR	[3] TC FR	[4] TC FR	[5] TC FR	[6] TC FR	[7] TC FR	[8] TC FR	[9] TC FR	[10] TC FR	[11] TC FR	[12] TC FR
M^2	0.000720***	0.000684***	0.000706***	0.000728***	0.000786***	0.000710***	0.000669***	0.000784***	0.000811***	0.000796***		
	(4.288)	(5.689)	(7.026)	(7.579)	(8.548)	(7.895)	(7.363)	(8.757)	(8.715)	(8.394)		
BHP	3.54e-06	3.05e-06										
	(0.375)	(0.328)										
DWT	-9.76e-06											
	(-0.305)											
DP2	0.0697*	0.0700*	0.0721**	0.0720**								
	(1.913)	(1.926)	(2.014)	(2.011)								
Age	-0.00730***	-0.00717***	-0.00723***	-0.00737***	-0.00925***	-0.00838***	-0.00890***					
	(-3.379)	(-3.390)	(-3.436)	(-3.516)	(-4.913)	(-4.448)	(-4.653)					
Duration	-0.000183***	-0.000182***	-0.000182***	-0.000187***	-0.000186***	-0.000213***	-0.000210***	-0.000197***	-0.000191***	-0.000212***	-0.000227***	
	(-7.185)	(-7.197)	(-7.198)	(-7.675)	(-7.641)	(-9.148)	(-8.890)	(-8.194)	(-7.648)	(-8.509)	(-8.446)	
Days Forward	-0.000286***	-0.000289***	-0.000285***	-0.000284***	-0.000299***							
	(-3.058)	(-3.115)	(-3.101)	(-3.089)	(-3.254)							
Production	-0.342***	-0.343***	-0.344***	-0.343***	-0.356***	-0.328***	-0.340***	-0.332***	-0.140***			
	(-7.658)	(-7.762)	(-7.788)	(-7.770)	(-8.141)	(-7.560)	(-7.736)	(-7.368)	(-4.239)			
Drilling	-0.329***	-0.332***	-0.333***	-0.330***	-0.346***	-0.319***	-0.330***	-0.297***				
	(-6.580)	(-6.740)	(-6.809)	(-6.777)	(-7.171)	(-6.635)	(-6.750)	(-6.006)				
Brazil	-0.0423	-0.0420	-0.0440									
	(-0.707)	(-0.704)	(-0.741)									
Oil Price	0.00390***	0.00390***	0.00388***	0.00384***	0.00382***	0.00400***						
	(3.934)	(3.946)	(3.937)	(3.901)	(3.874)	(4.012)						
Spot	9.86e-06***	9.85e-06***	9.85e-06***	9.92e-06***	9.96e-06***	9.51e-06***	1.03e-05***	1.02e-05***	1.08e-05***	1.14e-05***	1.17e-05***	1.17e-05***
	(9.224)	(9.229)	(9.244)	(9.350)	(9.349)	(8.903)	(9.592)	(9.327)	(9.554)	(9.885)	(9.482)	(8.788)
Oil Production	2.24e-05***	2.23e-05***	2.23e-05***	2.25e-05***	2.32e-05***	2.24e-05***	3.91e-05***	4.01e-05***	4.13e-05***	4.03e-05***	4.50e-05***	4.45e-05***
	(4.143)	(4.136)	(4.138)	(4.193)	(4.316)	(4.116)	(10.96)	(11.01)	(10.93)	(10.48)	(10.96)	(10.05)
Constant	0.217	0.252	0.263	0.149	-0.109	0.256	-6.173***	-6.765***	-7.494***	-7.172***	-8.444***	-8.361***
	(0.102)	(0.120)	(0.125)	(0.0706)	(-0.0519)	(0.120)	(-4.337)	(-4.661)	(-4.982)	(-4.682)	(-5.140)	(-4.719)
Observations	434	434	434	434	434	434	434	434	434	434	434	434
R-squared	0.625	0.624	0.624	0.624	0.620	0.611	0.596	0.576	0.540	0.520	0.442	0.349

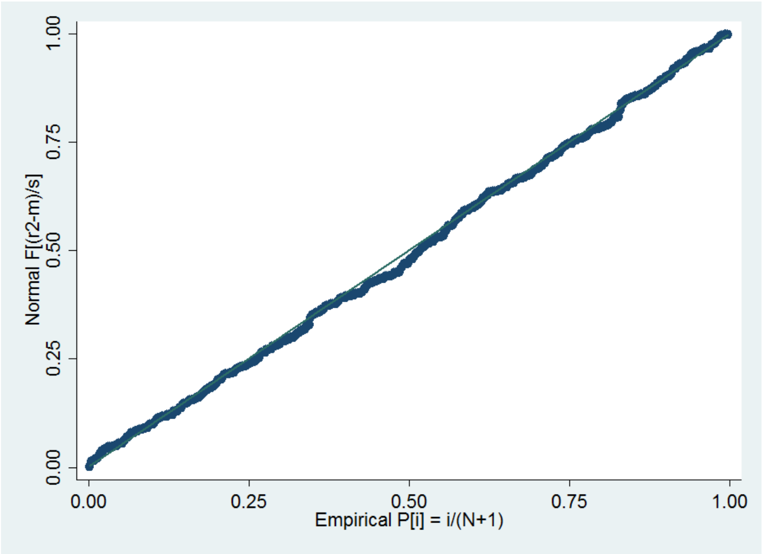
t-statistics in parentheses

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

Appendix 4.4 2004-2008 - Residuals versus Fitted Plot



Appendix 4.5 2004-2008 - Residual Normality Plot



Appendix 4.6 2004-2008 - VIF Test

Variable	VIF	1/VIF
M^2	4,05	0,24691
DWT	3,97	0,25189
Oil Price	2,71	0,36900
Oil Production	2,67	0,37453
Drilling	2,38	0,42017
Production	2,32	0,43103
BHP	2,15	0,46512
DP2	1,56	0,64103
Age	1,51	0,66225
Days Forward	1,37	0,72993
Duration	1,3	0,76923
Brazil	1,3	0,76923
Monthly Spot	1,14	0,87719
Mean VIF	2,19	

Appendix 4.7 2004-2008 - Durbin-Watson Test

Durbin-Watson test	
Sum Of Difference Squared Residuals	62,314
Sum Of Squared Residuals	37,974
Durbin-Watson D-value	**1,641**

Appendix 5.1 2009-2015 - Correlation Matrix

	TC FR	M^2	BHP	DWT	DP2	Age	Duration	Days Forward	Production	Drilling	Brazil	Oil Price	Monthly Spot	Oil Production
TC FR	**1**													
M^2	0,22	**1**												
BHP	0,23	0,73	**1**											
DWT	0,22	0,89	0,71	**1**										
DP2	0,17	0,36	0,38	0,33	**1**									
Age	-0,17	-0,21	-0,28	-0,28	-0,45	**1**								
Duration	0,26	-0,15	-0,11	-0,08	-0,11	-0,22	**1**							
Days Forward	0,23	0,02	0,08	0,04	0,00	-0,28	0,61	**1**						
Production	-0,25	0,05	0,10	0,06	-0,04	0,05	-0,12	-0,19	**1**					
Drilling	0,17	0,02	-0,05	0,03	0,05	-0,16	0,16	0,19	-0,82	**1**				
Brazil	0,30	-0,41	-0,38	-0,34	-0,21	-0,01	0,66	0,35	-0,22	0,21	**1**			
Oil Price	0,46	0,08	0,04	0,04	0,03	0,03	0,01	0,03	-0,16	0,13	0,08	**1**		
Monthly Spot	0,35	-0,08	-0,08	-0,07	-0,08	0,07	0,04	0,07	-0,02	0,04	0,07	0,28	**1**	
Oil Production	0,05	0,18	0,21	0,17	0,10	0,02	-0,11	-0,02	-0,02	0,03	-0,08	0,17	0,05	**1**

Appendix 5.2 2009-2015 - Descriptive Statistics

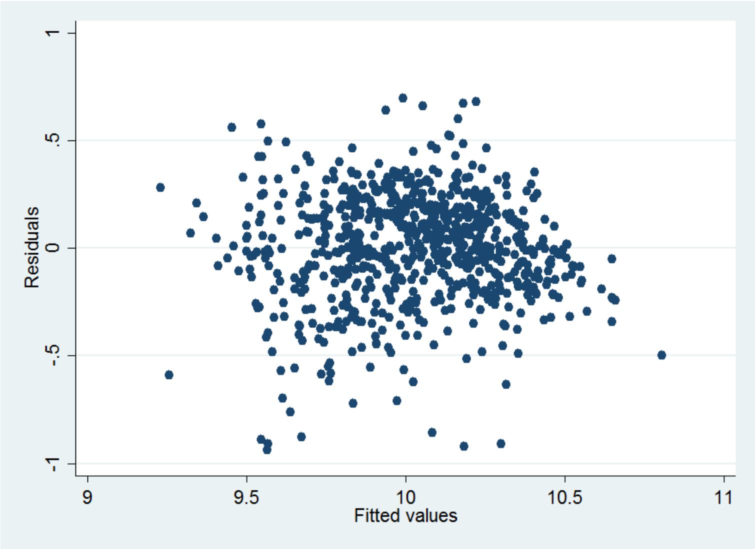
Stats	TC FR	M^2	BHP	DWT	Age	Duration	Days Forward	Oil Price	Monthly Spot	Oil Production
Mean	24195	820	7577	3959	7	662	95	95	17490	422061
Median	24422	844	7026	4000	4	260	23	102	16579	419520
Max	54488	1270	14000	7620	32	2952	1878	126	42280	454951
Min	5586	250	2250	1407	-5	28	0	43	5579	396607
SD	7857	177	2334	984	7	772	225	20	8201	12454
SD / Mean	286,32	6,47	85,00	35,84	0,26	28,12	8,21	0,74	298,86	453,83
Skewness	0,18	-0,37	0,41	0,08	1,27	1,40	4,47	0,62	0,74	0,65
Kurtosis	3,00	2,76	2,58	3,75	4,33	4,26	26,16	2,36	3,26	3,20

Appendix 5.3 2009-2015 - Regression 1-12

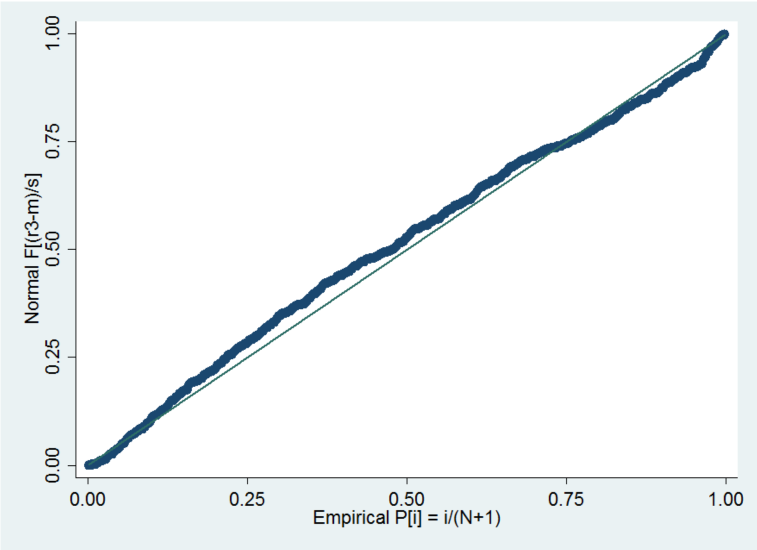
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
Variables	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR	TC FR
M^2	0.000377***	0.000373***	0.000375***	0.000451***	0.000443***	0.000435***	0.000472***	0.000416***				
	(3.059)	(3.035)	(3.053)	(5.772)	(5.656)	(5.510)	(5.974)	(5.218)				
BHP	3.42e-05***	3.38e-05***	3.42e-05***	3.51e-05***	3.78e-05***	3.56e-05***	3.96e-05***	4.06e-05***	6.15e-05***	6.07e-05***	5.75e-05***	
	(5.577)	(5.549)	(5.644)	(5.889)	(6.432)	(6.055)	(6.771)	(6.823)	(13.72)	(13.28)	(12.03)	
DWT	1.60e-05	1.67e-05	1.70e-05									
	(0.754)	(0.789)	(0.804)									
DP2	0.0690***	0.0699***	0.0677***	0.0660***	0.0898***	0.0884***						
	(2.836)	(2.879)	(2.814)	(2.754)	(4.086)	(3.995)						
Age	-0.00340**	-0.00325**	-0.00352**	-0.00374**								
	(-2.112)	(-2.046)	(-2.280)	(-2.459)								
Duration	1.71e-05	1.17e-05										
	(0.895)	(0.699)										
Days Forward	-3.13e-05											
	(-0.585)											
Production	-0.252***	-0.249***	-0.248***	-0.247***	-0.235***	-0.235***	-0.242***	-0.104***	-0.111***			
	(-7.683)	(-7.689)	(-7.670)	(-7.648)	(-7.336)	(-7.270)	(-7.420)	(-5.300)	(-5.550)			
Drilling	-0.194***	-0.193***	-0.193***	-0.192***	-0.175***	-0.176***	-0.176***					
	(-5.772)	(-5.749)	(-5.736)	(-5.718)	(-5.306)	(-5.302)	(-5.244)					
Brazil	0.313***	0.313***	0.327***	0.328***	0.336***	0.337***	0.331***	0.318***	0.292***	0.316***	0.320***	0.207***
	(10.43)	(10.45)	(14.33)	(14.41)	(14.92)	(14.85)	(14.48)	(13.75)	(12.69)	(13.72)	(13.23)	(8.525)
Oil Price	0.00565***	0.00566***	0.00565***	0.00562***	0.00557***	0.00534***	0.00536***	0.00545***	0.00571***	0.00613***	0.00740***	0.00789***
	(11.61)	(11.64)	(11.62)	(11.60)	(11.47)	(11.02)	(10.94)	(10.95)	(11.32)	(12.06)	(14.48)	(14.17)
Spot	1.25e-05***	1.25e-05***	1.25e-05***	1.25e-05***	1.24e-05***	1.23e-05***	1.21e-05***	1.17e-05***	1.13e-05***	1.10e-05***		
	(10.66)	(10.65)	(10.68)	(10.71)	(10.61)	(10.43)	(10.14)	(9.668)	(9.213)	(8.812)		
Oil Production	-2.33e-06***	-2.35e-06***	-2.40e-06***	-2.39e-06***	-2.58e-06***							
	(-3.046)	(-3.070)	(-3.151)	(-3.135)	(-3.399)							
Constant	9.708***	9.715***	9.737***	9.733***	9.751***	8.709***	8.718***	8.621***	8.798***	8.704***	8.799***	9.224***
	(30.79)	(30.85)	(31.09)	(31.09)	(31.05)	(126.7)	(125.6)	(126.7)	(146.7)	(148.3)	(145.2)	(171.7)
Observations	753	753	753	753	753	753	753	753	753	753	753	753
R-squared	0.535	0.535	0.534	0.534	0.530	0.523	0.513	0.495	0.476	0.455	0.398	0.282

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 5.4 2009-2015 - Residuals versus Fitted Plot



Appendix 5.5 2009-2015 - Residual Normality Plot



Appendix 5.6 2009-2015 - VIF Test

Variable	VIF	1/VIF
M^2	5,77	0,17331
DWT	5,24	0,19084
Production	3,25	0,30769
Drilling	3,23	0,30960
Duration	2,64	0,37879
BHP	2,47	0,40486
Brazil	2,33	0,42918
Days Forward	1,76	0,56818
Age	1,57	0,63694
DP2	1,48	0,67568
Oil Price	1,17	0,85470
Monthly Spot	1,12	0,89286
Oil Production	1,1	0,90909
Mean VIF	2,55	

Appendix 5.7 2009-2015 - Durbin-Watson Test

Durbin-Watson test	
Sum Of Difference Squared Residuals	69,074
Sum Of Squared Residuals	45,989
Durbin-Watson D-value	**1,502**