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Offshore support vessels market: sales & purchase, and chartering strategies for PSV and AHTS : an evaluation of the influential factors

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OFFSHORE SUPPORT VESSELS MARKET:

Sales & purchase, and chartering strategies for PSV and AHTS: an evaluation of the influential factors.

By

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A dissertation submitted to the World Maritime University in partial Fulfilment of the requirements for the award of the degree of

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Declaration

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

(Signature): ………………………..

(Date): September 23rd - 2019

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Port Management Specialization

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Abstract

Title of Dissertation:	**Sales & purchase, and chartering strategies for PSV and AHTS: an evaluation of the influential factors.**
Degree:	**Master of Science**

This paper examines and evaluates market strategies for term-contract fixtures and sales & purchases (S&P) in different segments of the Offshore Support Vessels (OSV) service market from the context of the global offshore oil and gas industry, and identifies the factors that influence the second-hand price (SHP) and term charter rates (T/C rates) of Anchor Handling Tug Supply vessels (AHTS) and Platform Supply Vessels (PSV) of different characteristics. The OSVs are essential for the energy industry as these vessels transport the vast majority of equipment, tools, and materials to the offshore units along with other crucial support duties including the towage of offshore units such as Jack-Up drilling rigs or offshore production units. T/C rates and SHP fluctuations have not been thoroughly investigated, and only a limited number of studies examining its behaviour and characteristics regionally are found. This study builds Ordinary Least Squares (OLS) Autoregressive Moving Average (ARMA) Generalized Autoregressive Condition Heteroskedasticity (GARCH) models to analyse the presence of volatility clusters and leverage effect for second-hand and T/C markets in the offshore industry, and to determine various factors affecting them. The research concludes that long-term fixtures (1 year) generate higher return compared to short term contracts. It is also observed that buy and hold strategy for the second-hand vessel market is only providing a 3 to 4-month opportunity window which may not be sufficient for generating profit.

KEYWORDS: ARMA GARCH Models; Offshore Support Vessels; Anchor Handling Tug Supply; Platform Supply Vessels; Offshore Oil and Gas; Offshore Shipping; Term Charter Rate; Second-Hand Price; Offshore Logistics.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

5yo	Five years old
ADF	Augmented Dickey and Fuller
AHTS	Anchor Handling Tug Supply
ARMA	Autoregresive Moving Average
BHP	Breaking Horse Power
BLUE	Best Linear Unbiased Estimators
BP	Bollard Pull
CLRM	Classical Linear Regression Model
DP	Dynamic Positioning
DS	Drillships
DWT	Dead Weight Tonnage
E&P	Exploration and Production
ECT	Error Correction Terms
FPSO	Floating Storage and Offloading units
GARCH	Generalized Autoregressive Condition Heteroskedasticity
GoM	Gulf of Mexico
IOC	International oil company
JB	Jarque – Bera
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LIBOR	London Inter-Bank Offered Rate
MA	Moving Average
MAE	Mean Absolute Error
MAPE	Mean Absolute Percentage Error

MGO	Marine Gas Oil
MODU	Mobile Offshore Drilling Units
MOPU	Mobile Floating Offshore Mobile Production Units
MSE	Mean Squared Error
N-W	Newey-West
NOC	National oil company
OIN	Offshore Intelligence Network
OLS	Ordinary Least Square
OPEC	Organization of the Petroleum Exporting Countries
OSV	Offshore Support Vessels
PP	Phillips and Perron
PSV	Platform Supply Vessels
SHP	Second-hand price
SS	Semi-submersible
T/C Rate	Term Charter Rate
TLP	Tension Leg Platform
VAR	Vector Autoregression
VLCC	Very Large Crude Carrier
WAFR	World Average Freight Rate

1 Introduction

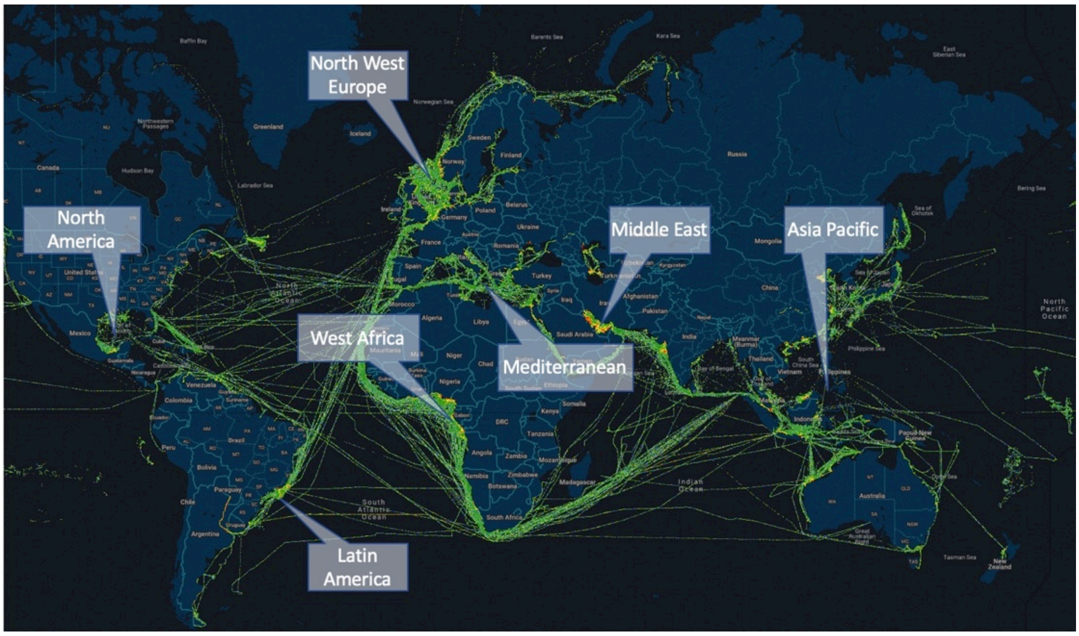
1.1 Background Context

The commercial offshore oil and gas industry started around 1947 with the drilling and completion of the first profitable offshore wells located off the coast of Louisiana in the United States. Since then, oil companies have been progressively seeking hydrocarbons in farther offshore locations (International Energy Agency, 2018). Offshore hydrocarbon operations have been growing in water depth and distance from shore, and so has the maritime services industry that supports this specialized segment. These services are a combination of the maritime industry and the oil and gas (O&G) sector. As the offshore operation goes farther from shore, the necessity of specialized means of transportation like Offshore Support Vessels (OSV) has increased. In recent years, new markets have been actively growing around the world.

The OSV market is divided into two main segments: The Platform Supply Vessels (PSV) and the Anchor Handling Tug Supply (AHTS) vessels. The former are mainly the vessels supporting the transportation and delivery of oil field materials, tools and equipment to the drilling rigs or offshore installations from onshore supply bases, whilst the latter are mainly dedicated to support the drilling rigs' movements and towage operations, and are also capable to perform supply duties (Clarksons Research Services, 2019d). The categorization of the PSV fleet is typically by Dead

Weight Tonnage[1] (DWT) or the deck area (depending the operational region) of the vessel. On the other hand, the AHTS fleet is differentiated by the Breaking Horse Power[2] (bhp) of the vessel. Both types of OSVs are deployed and operate in the main offshore operational regions, as presented in Figure 1.

***Figure 1.* Offshore Support Vessels Density Map**



Note: Adapted from Seanet Live Map by Clarksons Research Services. (2019). Offshore intelligence network. Retrieved from https://www.clarksons.net/oin/

The price of energy is, to some extent, the standard indicator of how the oil market operates, influencing the long-term investment decisions of oil companies (Equinor, 2018). Fluctuations in the oil price have been influencing the day rates in the OSV market and have a direct influence on the drilling rigs market and production activity (Ådland, Cariou, & Wolff, 2017). As reported by Clarksons Research Services (2019), in 2009 the oil price dropped to $45 per barrel, followed by an active recovery in 2011 with Brent Crude prices exceeding $100 per barrel, and another price collapse in 2016, where oil price touched a historical minimum of around $30 per barrel. Today

[1] Deadweight (dwt). The weight a ship can carry when loaded to its marks, including cargo, fuel, fresh water, stores and crew (Stopford, 2009) .

[2] bhp is This is an important gauge of the size of the unit as it indicates the towing strength of the vessel. The largest anchor handlers in the fleet are over 30,000 bhp (Clarksons Research Services, 2019a).

the OSV market segment is still recovering from the last collapse of the oil price, as reflected by the current low term charter rates (T/C rates) and second-hand price (SHP), and the high number of laid-up OSVs - 127 vessels circa January 2015 against 1,400 circa January 2019 (Clarksons Research Services, 2019c). This suggests that the demand and supply balance still need to recover. An understanding of the T/C Rate and SHP influential elements and the dynamics of the OSV market is therefore essential when establishing strategies that benefit shipowners and charterers.

1.2 Problem Statement

Few studies have been found regarding the OSV market in terms of T/C rates or second-hand price. Ådland et al. (2017) are one of the firsts to explore the spot market T/C rates in the North Sea by developing a freight market index using detailed information contained in each of the transactions. The literature investigating T/C rates or SHP is mainly related to tankers and the dry bulk segment, with several findings determining the seasonality of the spot and time freight rates (Kavussanos & Alizadeh, 2001), (Kavussanos & Alizadeh, 2002b), (Alizadeh & Nomikos, 2006), (Alizadeh & Talley, 2011), among others.

The dynamics of the T/C rates and SHP for the OSV market have not been thoroughly investigated from a global perspective yet. The OSVs are highly specialized and complex units that operate in very capital intense scenarios and complex logistics frameworks around the world. The importance of the OSV to the energy industry is fundamental as these vessels transport the vast majority of equipment, tools, and materials to the offshore units (Kaiser, 2015), and not only in the O&G industry, which is the main focus of this research, but recently to the offshore wind industry. It is worth highlighting the vital role of the OSV in supporting the actual O&G projects and to anticipate how essential these types of vessels will be for the offshore units decommissioning cycle, since the International Energy Agency (2018) estimates that by 2040 between 2,500 and 3,000 O&G projects would be reaching their operational lifetime. These considerations are the main motivations for the performance of this research, principally, to contribute with some first steps in gaining a deeper understanding of this market by analysing the fundamental factors influencing this specialized segment of the shipping industry.

1.3 Objectives

The purpose of this study is to identify baseline elements of the dynamics of the OSVs service market which is supporting the offshore O&G industry and determine the relationship of these different variables from a global standpoint. These dynamics are required when evaluating chartering and sales and purchases timings and opportunities. The specific objectives of this study are:

- Discuss a trading strategy for chartering of PSVs and AHTS vessels in the context of the global O&G offshore market.
- Discuss an investment strategy for Sales and Purchase (S&P) of second-hand PSV and AHTS in the context the global O&G offshore market.

1.4 Methodology

This research utilized quantitative methods based on the application of econometric techniques to build Ordinary Least Squares (OLS) Autoregressive Moving Average (ARMA) Generalized Autoregressive Condition Heteroskedasticity (GARCH) empirical models using a set of unique second-hand 10 years monthly time series dataset obtained from Clarksons Offshore Intelligence Network (OIN). The regressions and forecasts were carried out using EViews 10 University Edition and followed OLS model building steps (Sahoo, 2019) presented in Appendix 1. The summary of the empirical steps involved in the construction of the econometric models are as follows:

1) Review of the financial theory to build a theoretical framework of selected variables able to explain the dependent variable
2) Data collection

3) Validate data (graph dependent and independent variables and analysis)

4) Estimate descriptive statistics for the variables

5) Determine correlation between variables

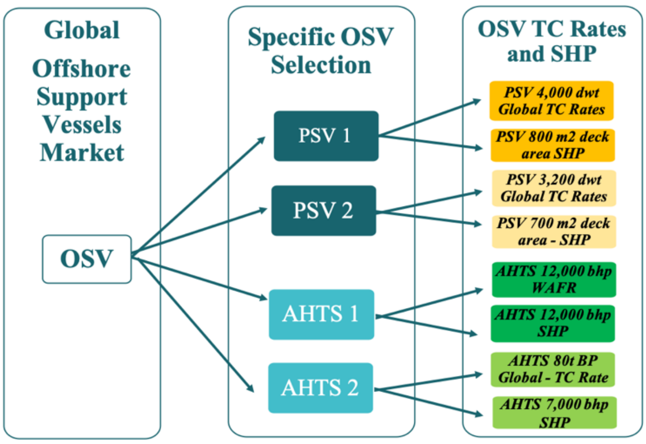
6) Estimate the regressions and testing of residuals – GARCH models' estimation

7) Validate R^2 coefficients and statistical significance of variables

8) Model interpretation and usage – Testing results

The dependent variables presented in Figure 2 represent the four most predominant types of OSVs and are divided into subsections, T/C rates and SHP respectively, for a final estimation of eight regressions (four for T/C rates and four for SHP). The interpretation and testing of the results for the models were the baseline for the researcher to determine the different performances of the chartering strategies and identify possible strategies for the S&P segment of the OSV shipping market. Capturing volatility clustering in the model supports the decision-making process.

Figure 2. Dependent Variables Synopsis



Note: The selected OSVs are divided in four different types of PSVs and AHTS. Equivalent pairs of PSV and AHTS are color coded. The final OSVs are the selected dependent variables to built the regressions, which for this study are eight in total; four for TC Rate and four for SHP. WAFR means World Average Freight Rate and BP is Bollard Pull. Dependent variables are in *italics.*

1.5 Research Scope

This study intended to discuss chartering and S&P strategies for four different types of OSVs in the context of the global offshore O&G operation through the building of eight regressions to explain T/C rates and SHP.

1.6 Outcomes

Valuable results are obtained from this study. Firstly, the influential variables significant to the T/C rates and SHP for different types of OSVs and benchmark[3] variables were identified. A strong influence (competition) among the PSV and AHTS segments were found. It was possible to explain the relationship between elements of different nature of the offshore O&G operation that are significant to the evaluated variables. Secondly, the performance of the T/C rate was tested under actual market conditions and forecasted markets. The long-term fixtures (1 year) showed a higher return than the strategy of fixing shorter contracts. The latter seek the benefits of forecasted T/C rate increments for upcoming contracts. Thirdly, the SHP market was found to be risky and challenging in terms of achieving benefits under the current market situation. The timing for the operations and transactions are factors that strongly impact investment and divestment decisions. The short forecasted-window of the bullish markets, which makes it difficult to profit from the S&P segment was also examined.

1.7 Research Contribution

This study provides to industry practitioners a perspective of the OSV market dynamics, as well as tools to envisage chartering and S&P strategies. It was possible to detect '*hold' or 'buy and hold'* signals by observing the identified variables that influence the second-hand price of OSVs, likewise, forecasting bullish or bearish windows duration and different OSV asset prices. Similarly, the chartering scenarios

[3] Are considered as benchmark variables the ones that influence the highest number of dependent variables analyzed in this study.

tested herein advise caution when defining chartering strategies. A simple comparison of the historical monthly increments in the term charter rates and second-hand price of OSVs with the forecasted rates is useful when deciding between fixing short- or long-term contracts. This is helpful for shipowners, charterers, ship managers or companies looking to diversify their portfolios or improve operational decisions and costs.

The contribution to academia is twofold. First, this study continues in exploring the Offshore Support Vessels market, and present models that may be used as a starting point in future researches within the OSV sector. Secondly, it uses and compiles a dataset that has not been used previously in building OLS ARMA GARCH models in this specialized market.

1.8 Research Structure

The remaining chapters of this study are structured as follows: Chapter 2 presents the literature review and is divided into three segments (deep-sea shipping, offshore segment and conceptual framework). Chapter 3 contains the data and methodology section and describes the steps to build the OLS ARMA GARCH models. It also contains the analysis and description of the dependent and independent variables selected for the models. Chapter 4 covers the findings after the regressions-built process and presents the relevant outcomes from the models. Chapter 5 includes the discussion and the applications of the results of the models, and presents the results of the test and the evaluation of the trading strategies. Chapter 6 contains essential conclusions of the research, some limitations, and recommendation for further studies.

2 Literature Review

2.1 General Shipping Industry

In the maritime economics literature, various empirical studies have examined different segments of the shipping markets[4], particularly the ones investigating the dynamics of the freight market and the S&P of the diverse type of merchant vessels engaged in maritime transport.

A recent study Ådland et al. (2017) suggests that the previous studies on freight rates' behaviour are generally divided into two main approaches. The first is the usage of time-series to develop empirical models to represent the freight rates, and the second is using the microdata contained in individual fixtures of vessels to evaluate the factors affecting the rates, to determine business opportunities.

The work of Kavussanos (1996), incorporates the application of Autoregressive Conditional Heteroskedasticity models to analyse the volatility of the freight market as an influential factor when choosing amongst time or spot term charters in the dry bulk sector. Kavussanos and Alizadeh (2001) empirically explore the freight rate seasonality for contracts of different terms in the dry bulk sector, suggesting the convenience of the application of ARMA and Vector Autoregression

[4] The four markets that control shipping: 1) The Freight Market, 2) The Sales and Purchase Market, 3) The Shipbuilding Market and 4) The Demolition Market (Stopford, 2009).

(VAR) models to support short and long run strategies according to the seasonal dynamics of the freight rates.

In his evaluation of trading rules based on statistical tests of the bulk shipping market, Ådland (2000) concludes that the volatility of the returns derived from trading strategies based on buy-signals is lower than the volatility of the returns resulting from sell-signals, and moreover, is inferior to the volatility of the returns of buy-and-hold strategies. Ådland's study also concludes that trading rules that presented superior performance provide higher positive investment returns on bullish markets, however Ådland and Koekebakker (2004) argue that when the information from illiquid bearish markets and the effect of transaction cost is considered, the evidence of superior performance diminishes, except in the Panamax bulk carriers' market. Studies of Kavussanos and Alizadeh (2002a) apply VAR models to analyse the vessel price dynamics resulting from the difference between theoretical prices and actual market prices in the dry bulk sector. These suggest that for periods where vessels are under-priced (meaning that theoretical prices are below the actual market prices), the purchase strategy responds to the expectation that the actual price would rise above the theoretical value, which represents future profits.

The information produced from the relationship between the vessel price and earnings stimulate S&P strategies. Alizadeh and Nomikos (2007) utilized simple Moving Average (MA) rules to devise the timing to sell or purchase ships based on the price of the asset derived from this relationship, they conclude that the cumulative returns based on simple MA-based strategies have evidenced superior performance to that of the buy-and-hold alternative, underlining the benefit resulting from the application of trade rules when making investment or divestment decision in the dry bulk shipping market.

The influential factors affecting tanker freight rates and tanker prices are widely covered in the maritime economics literature. Alizadeh and Talley (2011) investigated at a microeconomic level the dynamics between freight rate of liquid bulk carriers, Very Large Crude Carriers (VLCC), Suezmax and Aframax, the extent of laycan periods, the age of the ship and the voyage routes. They concluded, from the charterers' perspective that the covenant of a laycan period affects the charter rate, and on the other hand, the volatility of the freight rate affects the choice of a proper laycan period. For the second-hand market Tsolakis, Cridland and Haralambides (2003) propose an econometric model to forecast the second-hand price of vessels and identify its cycles, arguing that the orderbook percentage of new builds negatively affects the second-hand price of large tankers such as VLCC, Suezmax, and Panamax. Timing for S&P in the tanker market were examined by Alizadeh and Nomikos (2006). The study identified that the co-integration between tanker price and the freight rate possess important information to anticipate the future dynamics of the vessel price in order to decide on investment or divestment strategies. The study also found that trading rules complemented by essential market examinations perform better for large tankers such as VLCC or Aframax.

2.2 Offshore Shipping Industry

The offshore support vessels market differs from the classic deep-sea shipping industry and so does the literature. Since the early days of the offshore O&G activities, the OSV have been a fundamental link in supporting the development of the offshore industry. Milaković, Ehlers, Westvik and Schütz (2014), Kaiser (2015) and Ådland et al. (2017) agreed that until today little has been written regarding offshore logistics, particularly with respect to OSVs rates and prices despite the importance of the service and the high dependence of the industry on it.

A literature search revealed some studies which explore the optimization of supply logistics by the application of vessels routing policies for the offshore supply operations in the North Sea by Fagerholt and Lindstad (2000), and the routing issue of the supply vessel serving offshore facilities; Aas, Bjørnar, Gribkovskaia, Halskau, and Shlopak (2007); Kisialiou, Gribkovskaia, and Laporte (2007); Andersson, Duesund, and Fagerholt (2011); Alehashemi and Hajiyakhchali (2018). There are also other contributions on topics related to offshore procurement strategies for oil firms in the

North Sea; Aas, Bjornar, Buvik, and Cakic (2008) and the evaluation of bidding process for offshore support vessels in Brazil; Maciel, Lima, Meza, and Gomes (2014).

Other studies have examined the offshore support vessels market from a regional operations perspective. Kaiser (2015) performs quantitative assessments on the operational activities of the offshore support vessels and explore the offshore logistics organization that upholds the O&G industry in the Gulf of Mexico (GoM). Kaiser and Snyder (2013) address the economic influence of the offshore shipping sector and the future regional perspectives for the shipyard industry in the United States, and similarly, Kaiser (2010) contributes in forecasting future demands of shipping service for the offshore industry in the GoM by developing methodological frameworks for this purpose. A recent investigation by Ådland et al. (2017) have empirically examined for the first time the offshore vessels spot market in the North Sea, generating a market index by using detailed information of individual transactions of PSVs and AHTS vessels from 1989 to 2005. The selected variables are primarily associated with the technical capabilities and specification such as bhp, DWT, deck area, age, Dynamic Positioning[5] (DP) system, speed and propulsion system of the vessels (among others) and the contracts duration. The study concludes that the freight rates are positively correlated with the power and capacity of the vessels, growing with the specification of the OSVs, and suggest that the spot market is volatile and seasonal with higher rates during spring and summer.

The studies carried out on the offshore industry comprises of some significant aspects of the offshore shipping service. However, these contributions are limited to the offshore logistics operation, the technical segment of the marine component, or the safety and regulatory division of the offshore shipping sector. Only a few empirical studies have attempted to investigate the chartering market and fixtures of offshore

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[5] DP technology enables a vessel to maintain its position and heading using sophisticated positioning systems and control system technology for its own thrusters and propellers. It facilitates work in much deeper waters than vessels using traditional anchors and is widely used in the offshore oil and gas, renewable energy and related industries (IMCA, 2019) .

service vessels, and none explored trading strategies for chartering or sales and purchase of OSVs from a global standpoint.

2.3 Offshore Operation - Conceptual Framework

Upstream offshore logistics services are essential to the offshore exploration and production (E&P) industry, particularly for the drilling operations and the production phase, where the oil and gas operational period (drilling activities and oil production) are critical for the operator's finance (Alizadeh & Nomikos, 2006). "Supply operations and supporting logistics are two of the key operational segments required to have a high level of functionality in order to make offshore operations both economically and technically sustainable" (Milaković et al., 2014, p1) during all E&P cycles.

Kaiser (2010) and Milaković (2014) describe the offshore oil and gas E&P in four cycles: Exploration[6], Development[7], Production[8] and Decommissioning[9]. Figure 3 shows the E&P cycles and the average timeline of the most relevant activities from exploration to the decommissioning and Figure 4 shows the operational relationship between the primary elements of the operation, where the OSVs are the main link between inland logistics facilities and the offshore facilities.

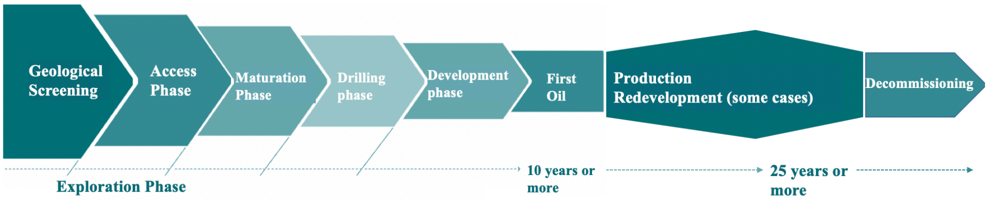
[6] 1) Exploration, which starts with geophysical surveys performed by seismic survey vessels followed by exploratory offshore drilling. This activity requires the drilling unit to be supplied by a considerable number of materials, dry and liquid bulks, equipment, and tools. This phase is highly dependent on the OSVs services, which are the main mean of transportation of cargo from and to the rig (1. Milaković et al., 2014) - (Kaiser, 2015).

[7] 2) The driver of the development cycle is the results of the exploratory wells and the decision of continuity by drilling production wells. This phase also comprises the construction and installation of production facilities and pipelines and has almost the same requirement of OSVs services because the drilling of development wells is similar to the exploratory drilling from a logistics standpoint (Milaković et al., 2014) - (Kaiser, 2015).

[8] 3) The production phase, which starts once the production unit is installed and commissioned, and the operator starts the hydrocarbons production. This phase usually lasts for a prolonged period, in some cases, more than 25 years. The requirement of OSVs is also essential due to the necessity of constant maintenance of the production wells and the requirement of supplies for the regular operation of the facility (Milaković et al., 2014) - (Kaiser, 2015).

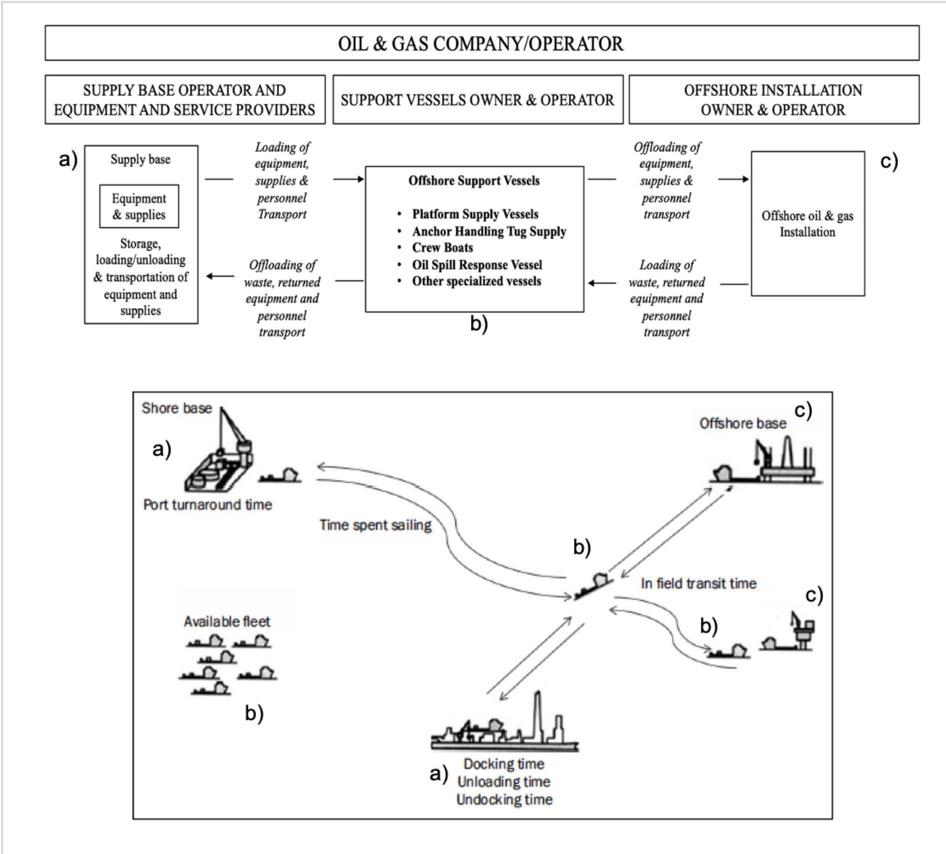
[9] 4) Decommissioning stage occur after the production of hydrocarbons is finalized, and the O&G company removes the production facilities from the location (Milaković et al., 2014) - (Kaiser, 2015).

Figure 3. E&P Life Cycle



Note: Adapted from "From idea to oil" by Equinor ASA 2019.
Retrieved from https://www.equinor.com/en/what-we-do/exploration.html

Figure 4. Offshore Operation Illustration



Note 1: Offshore operations diagram: representing the flow of oil field materials, tools and equipment to and from onshore supply bases (a). OSVs (b) are the main mean of transportation of the cargo to the offshore oil and gas installations and units.

Note 2: Adapted from Milaković, A., Ehlers, S., & Schütz, P. (2014). Offshore upstream logistics for operations in arctic environment. Paper presented at the International Maritime and Port Technology and Development Conference, Trondheim, Norway. 171-178. Retrieved from https://www.researchgate.net/publication/280921433_Offshore_upstream_logistics_for_operations_in_Arctic_environment , and Skoko, I., Jurčević, M., & Božić, D. (2013). Logistics aspect of offshore support vessels on the West Africa market. PROMET - Traffic & Transportation, 25(6), 587-593. https://doi.org/10.7307/ptt.v25i6.1258.

PSVs and AHTS services are essential at almost all stages of the offshore exploration and production activities regardless the distance or the water depth where the activities are performed (Skoko, Jurčević, & Božić, 2013). The operational elements described in the Tables 1, 2 and 3 are the majority of the variables identified to describe the dynamics of PSV and AHTS term charter rate and second-hand price, due to the operational interrelation between them. These elements together are the main components of the maritime segment of the offshore O&G operations worldwide.

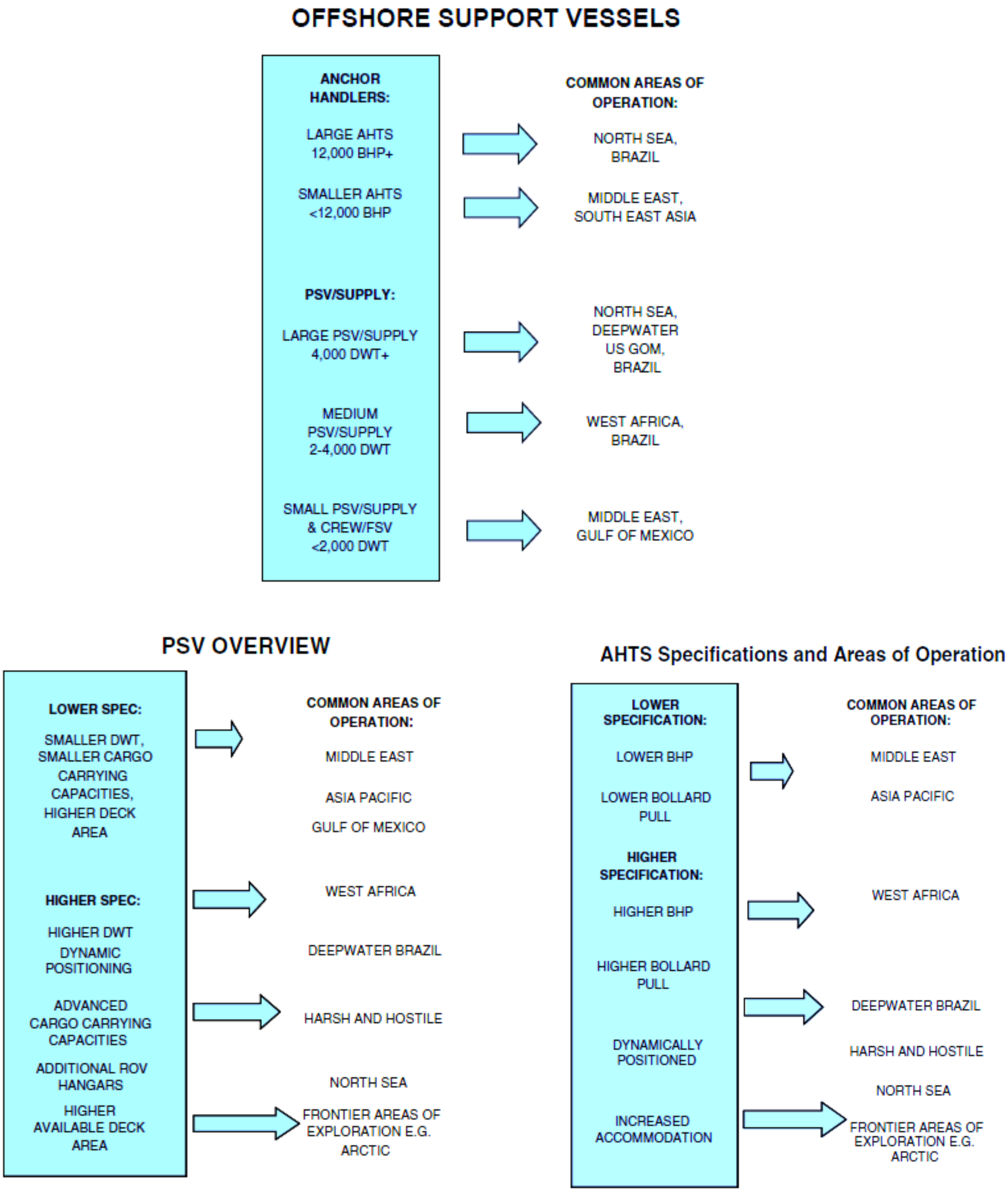
Table 1. Offshore Support Vessels Description

	OFFSHORE SUPPORT VESSELS (OSV)		
	Small Supply/Crew-work Vessels	PSV	AHTS
	 Source: Seacor Marine	 Source: Tidewater	 Source: Edison Chouest
E&P Cycle	Exploration Development Production	Exploration Development Production	Exploration Development Production
Role & Description	Typically operate close to shore in benign conditions, such as in shallow waters, are distinguished by higher speeds, though are equipped with smaller tank capacities to transport fuel and potable water to offshore rigs	The PSV is designed for supplying offshore drilling rigs and production platforms with necessary equipment, stores and drilling consumables	The AHTS combines a number of functions in a single hull. These include handling the anchors and mooring chains for drilling rigs, towing of rigs and platforms together with subsequent positioning on site, and platform supply duties
Total Fleet	396	1642	1982
Common Areas of Operation	Middle East Gulf of Mexico	4,000 DWT+ North sea Deepwater US GOM Brazil 2-4,000 DWT Brazil West Africa	12,000 BHP+ North sea Brazil <12,000 BHP Middle East South East Asia

Note: Information for the elaboration of the Table 1 retrieved from:
1) Petrobras. (2014). Types of platforms. Retrieved from http://www.petrobras.com.br/infographics/types-of-platform/desktop/index.html#.
2) Babicz, J. (2015). *Wärtsilä encyclopedia of ship technology* (2nd ed.). Helsinki: Wärtsiliä Corporation. Retrieved from https://www.wartsila.com/docs/default-source/marine-documents/encyclopedia/wartsila-o-marine-encyclopedia.pdf.
3) Clarksons Research Services. (2019). *The supply vessel register 2019* (9th ed.). London, England: Clarkson Research Services ltd.
4) Kaiser, M. J. (2015). *Offshore service industry and logistics modelling in the Gulf of Mexico* (2015th ed.). Cham: Springer. https://doi.org/10.1007/978-3-319-17013-8

Figure 5 presents an overview and brake-down of the types of OSVs included in this research and the common area of operation for PSV and AHTS according to Clarksons Research Services (2019).

***Figure 5*. Offshore Support Vessel Overview**



Note: Retrieved from "PSV Overview – AHTS Specifications and Area of Operation", Clarksons Research Services. (2019). The anchor handling tugs / supply register 2019 (23rd ed.). London, England: Clarkson Research Services ltd, and Clarksons Research Services. (2019). The supply vessel register 2019 (9th ed.). London, England: Clarkson Research Services ltd.

The Mobile Offshore Drilling Units (MODU) considered for this research and presented in Table 2, are the three main types of units operating in the offshore energy industry (excluding Mobile Drill Barges[10]): Jack-Up units or self-elevating rigs for shallow water operations, semi-submersibles (SS) for deep and ultradeep water drilling and Drillships (DS) or ship-shaped offshore drilling vessels. The last two are known as floaters and they can substitute each other (Clarksons Research Services, 2019a)

Table 2. Mobile Offshore Drilling Units (Offshore Installation)

	MOBILE DRILLING UNITS			
	Barge type drilling Rigs	**Jack-up Drilling Rigs**	**Semi-Submersible Drilling Rigs**	**Drillship**
	 Source: Parker Drilling	 Source: Maersk Drilling	 Source: Maersk Drilling	 Source: Maersk Drilling
E&P Cycle	**Exploration (main) Development**	**Exploration Development**	**Exploration Development**	**Exploration Development**
Role & Description	Modularized drilling unit moored to fixed of floating structures. Non Propelled	Self-elevating mobile offshore drilling unit. Set the legs on the seabed. Mobilizes between locations either under tow or aboard a heavy lift transportation vessel	Floating mobile drilling unit, stabilized by columns. Can be anchored on the seabed or equipped with a dynamic positioning system that automatically maintains the platform's position	Floating mobile drilling unit with a ship-shaped hull. These vessels can be anchored to the seabed or equipped with dynamic positioning systems, which maintain the vessel's position automatically
Total Fleet	113	553	139	111
Water Depth Capabilities	Shallow Waters	Up to 450 ft Water Depth	Latest Generation can operate in up to 12,500 feet.	Latest Generation can operate in up to 12,500 feet.

Note: Information for the elaboration of the Table 2 retrieved from:
1) Petrobras. (2014). Types of platforms. Retrieved from http://www.petrobras.com.br/infographics/types-of-platform/desktop/index.html#.
2) Babicz, J. (2015). *Wärtsilä encyclopedia of ship technology* (2nd ed.). Helsinki: Wärtsiliä Corporation. Retrieved from https://www.wartsila.com/docs/default-source/marine-documents/encyclopedia/wartsila-o-marine-encyclopedia.pdf.
3) Clarksons Research Services. (2019). *The supply vessel register 2019* (9th ed.). London, England: Clarkson Research Services ltd.
4) Kaiser, M. J. (2015). *Offshore service industry and logistics modelling in the Gulf of Mexico* (2015th ed.). Cham: Springer. https://doi.org/10.1007/978-3-319-17013-8

[10] Mobile Drilling Tenders and Mobile Drill Barges have applications in some areas of the world, but are not necessarily always considered as part of the mainstream Mobile Drilling Unit Fleet (Clarksons Research Services, 2019)

Table 3 presents the major types of Mobile Floating Offshore Mobile Production Units (MOPU). Floating Storage and Offloading units (FPSO), Tension Leg Platforms (TLP), Spar and semi-submersibles (SS). For shallow waters, the main production structures are the fixed production platforms and Jack-Up production units.

Table 3. Offshore Production Units description (Offshore Installations)

	PRODUCTION UNITS					
	Fixed Production Structures	**Jack-up Production Rigs**	**Semi-Submersible Production Rigs**	**SPARS**	**TLP/TLWP**	**FPSO**
	 Source: Aker BP	 Source: Global Systems	 Source: Chevron	 Source: Anadarko	 Source: Modec	 Source: Shell
E&P Cycle	**Production (main) Development**	**Production (main) Development**	**Production (main) Development**	**Production (main) Development**	**Production (main) Development**	**Production (main) Development**
Role & Description	Works as a rigid structure, fixed on the seabed by a system of driven piles	A Jack-Up Production Unit is a floating barge fitted with three or four supporting legs that can be raised or lowered as necessary	Semi-submersible production installation is permanently moored by eight to twelve point catenaries. This installation processes and off-loads hydrocarbons without storage capacity	Spar platform consists of a single, vertical, large diameter cylinder that support the topside. The hull is moored as a taut catenary system of six or more lines anchored into the seabed	Floating platform, with a hull similar to a semi-submersible's. It is anchored to the seabed by cables or tensioned steel tendons	Floating platform, in most cases converted from oil tankers. As is the case with the semi-submersible platform, it is anchored to the seabed
Production Flow	Pipelines	Pipelines	Pipelines or storage vessels and subsequent offloading at terminals	Pipelines or storage vessels and subsequent offloading at terminals	The oil is offloaded to a production platform (FPSO), which undertakes the processing and offloads it by ship	The oil is offloaded to tankers, which, in turn, offload it at the terminals
Total Fleet	9502	69	46	19	30	214
Common Deployment Areas	Worldwide	NW Europe SE Asia West Africa Middle East Mediterranean	Brazil North Sea US GoM	US GoM	US GoM	Brazil West Africa North Sea
Water Depth	Shallow Waters	Shallow Waters Up To approx. 400 m	Deep and Ultradeep Waters	Deep and Ultradeep Waters	Water Depth Greater than 300m	Deep and Ultradeep Waters

Note: Information for the elaboration of the Table 3 retrieved from:

1) Petrobras. (2014). Types of platforms. Retrieved from http://www.petrobras.com.br/infographics/types-of-platform/desktop/index.html#.

2) Babicz, J. (2015). *Wärtsilä encyclopedia of ship technology* (2nd ed.). Helsinki: Wärtsiliä Corporation. Retrieved from https://www.wartsila.com/docs/default-source/marine-documents/encyclopedia/wartsila-o-marine-encyclopedia.pdf.

3) Clarksons Research Services. (2019). *The supply vessel register 2019* (9th ed.). London, England: Clarkson Research Services ltd.

4) Kaiser, M. J. (2015). *Offshore service industry and logistics modelling in the Gulf of Mexico* (2015th ed.). Cham: Springer. https://doi.org/10.1007/978-3-319-17013-8

This section discussed the general structure of the offshore E&P operation and the different segments that interact with each other from a maritime perspective. This paper, unlike the previous ones examined in this literature review, assesses term charter and second-hand market of offshore support vessels from an offshore E&P operational standpoint, in the perspective of the maritime economics of PSVs and AHTS, and contributes to a global analysis of the freight rates and second-hand prices to define trading strategies. Figure 6 shows a typical offshore supply operation.

Figure 6. Offshore Operation Description

Note: Jack-Up rig and OSVs alongside the rig performing supply duties. Retrieved from: https://www.hartenergy.com/exclusives/boem-GoM-lease-sale-attracts-275-million-high-bids-29754

3 Data and Methodology

This chapter describes the conceptual steps to build the OLS ARMA GARCH regressions. These models are used to forecast and analyse the OSV market and define the investment strategies for S&P and chartering of PSV and AHTS.

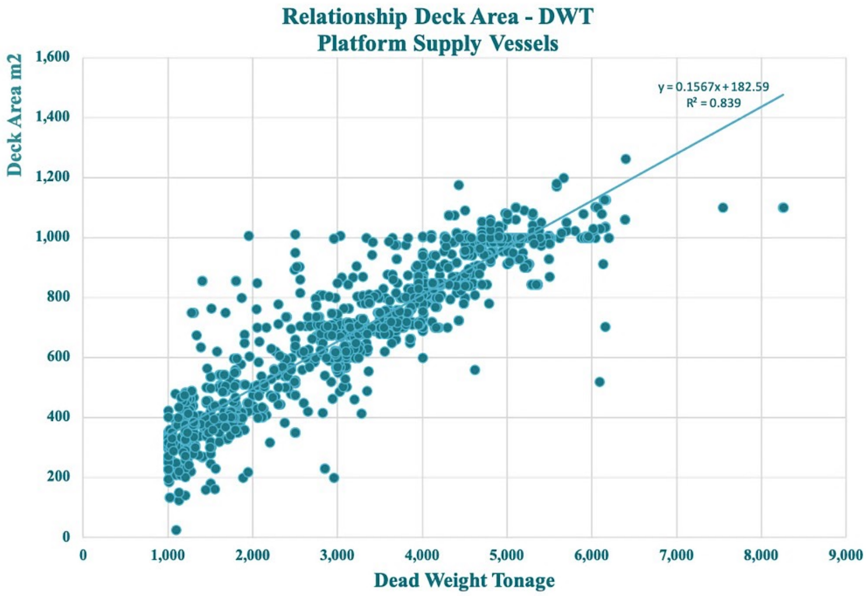
3.1 Data Description and Validation

Together with the description of the variables, a dataset analysis is performed to identify anomalies in the data pattern or any inconsistencies that may cause bias in the models. The first validation is through the visual inspection of each variable, followed by a graphical comparison between similar variables where the behaviour of the variable is compared.

3.1.1. Dependent Variables

The selection of appropriate variables is essential for the study, four types of OSV were chosen as dependent variables for the evaluation of the global term charter rate and five years old (5yo) price for PSV and AHTS, for a total of eight dependent variables. The specific characteristics in DWT and bhp of the vessels are the parameters to classify the OSVs accordingly, and based on a global screening, the vessels with higher market share and relevance in the market were chosen as dependent variables. The classification of PSVs according to its main characteristics vary from region to region, as it may change easily from operational area according to contractual requirements. Typically, in the GoM the classification of OSVs is according to the length or size in relation to DWT which is a common practice in the industry (Kaiser, 2015). In other regions the classification is according to the deck area in relation of DWT, as is the case of this study and shown in Figure 7. In the case of the AHTS (Figure 8), this study follows the relation between Bollard Pull[11] (BP) and bhp because this is the critical specification for these types of vessels. The nature of its design is to tow platforms or rigs and deploy anchors (Kaiser, 2015). Data for this specific analysis was retrieved from ODS Petrodata for 2014, and it represents a sample of 523 DP2[12] active AHTS worldwide.

Figure 7. **Relationship DWT - Deck Area for PSV worldwide circa 2019**

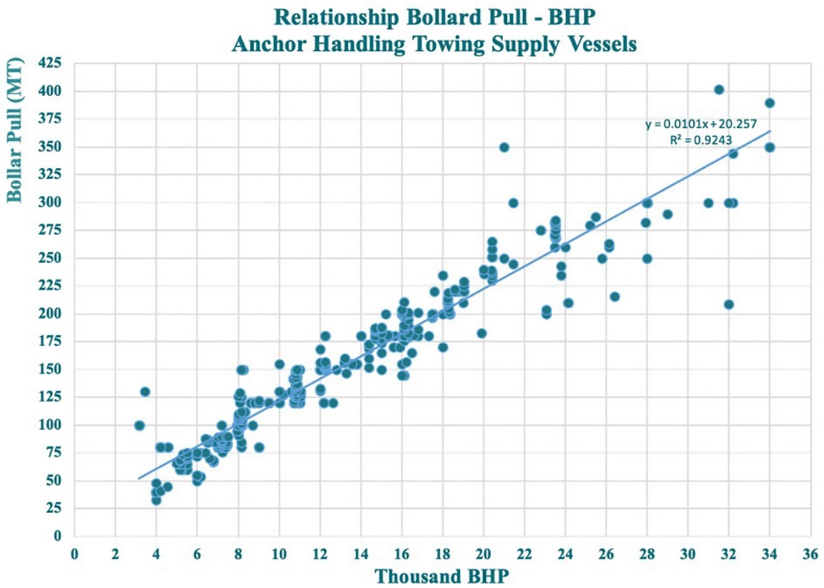


Note: the graph present the relationship deck area and Dead Weight Tonnage (DWT) of 1,642 PSV. The information was retrieved from the technical specifications reported by Clarksons Offshore Intelligence Network (OIN) for each vessel. This graph is used to determine the equivalence of vessels since the T/C rates are reported by Clarksons in DWT and the second-hand prices in DWT.

[11] Bollard Pull: The thrust developed at zero ahead speed. Bollard pull is the most commonly used measure of ship-assist tugs performance which have propellers optimized for maximum thrust at close to zero speed .(Babicz, 2015).

[12] DP2: Dynamic positioning system with redundancy in technical design and with an independent joystick system back-up (Det Norske Veritas, A S, 2011).

Figure 8. **Relationship BP - bhp Active AHTS – DP2 worldwide circa 2014**



Note: the graph present the relationship Bollard Pull (BP) and Breaking Horse Power (BHP) of 523 DP2 AHTS worldwide. The information was retrieved from the technical specifications reported by ODS Petrodata for 2014 for each vessel. This graph is used to determine the equivalence of vessels since the T/C rates are reported by Clarksons in BHP and the second-hand prices in BP.

The summary of the market share per vessel type is shown in Table 4. This analysis used data from Clarksons – Offshore Intelligence Network (OIN) database circa July 2019 and comprises of all the vessels registered in the OIN; 1,642 PSV and 1,982 AHTS worldwide.

Table 4. PSV - AHTS World fleet distribution by region

(Circa July 2019)

	AHTS - BHP/Region					**PSV - Deck Area/Region**			
Region	**16,000 BHP+**	**12-16,000 BHP**	**8-12,000 BHP**	**4-8,000 BHP**	**<4000 BHP**	**4,000 DWT+**	**3-4.000 DWT**	**2-3.000 DWT**	**<2,000 m2**
West Africa	13	19	46	132	15	44	84	15	34
North America	13	25	19	42	10	119	70	102	163
Latin America	35	21	15	26	5	116	44	17	65
Mediterranean	11	13	25	147	11	22	43	4	16
NW Europe	77	23	11	20	1	170	89	11	9
Asia Pacific	49	84	140	434	26	63	67	21	52
Middle East/ISC	4	11	44	376	39	13	69	38	82
Total By BHP/DWT	**202**	**196**	**300**	**1177**	**107**	**547**	**466**	**208**	**421**
Total			**1982**				**1642**		
Market Share	**10%**	**10%**	**15%**	**59%**	**5%**	**33%**	**28%**	**13%**	**26%**

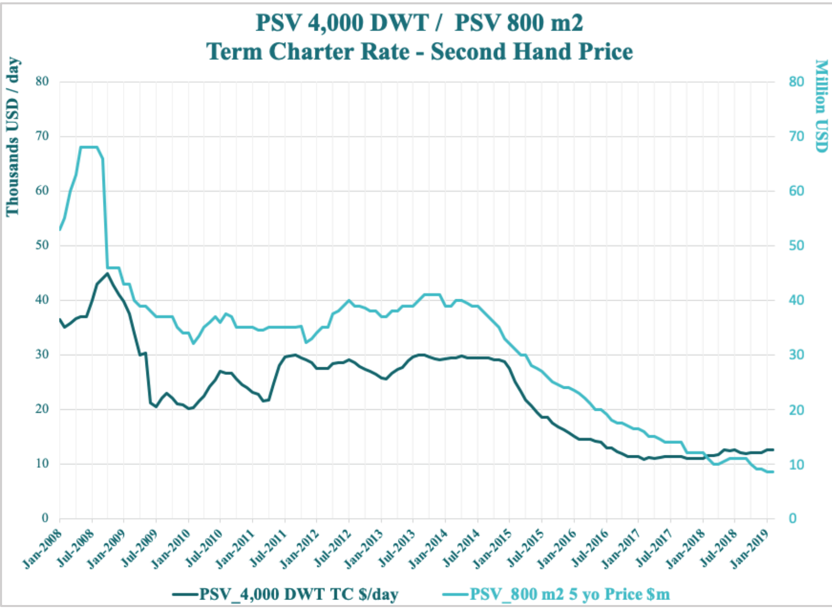
Data Source: Clarksons Offshore Intelligence Network

The following are the pairs of equivalent dependent variables selected for the models after the global screening and the deck area and DWT relation analysis:

PSV 4,000 DWT – T/C Rate Global, and PSV 800 m^2 deck area – 5yo SHP; These are predominant vessels in the global PSV market with 33% of market share. These vessels are designed to transport supplies over long distances, performing supply duties at offshore facilities, frequently in harsh environment areas such as Brazil, North Sea, Barents Sea or the Artic. These types of PSVs also have a significant market share in the United States GoM and Latin America (Clarksons Research Services, 2019). The T/C rates, and 5yo second-hand price are shown in Figure 9. It can be observed from the figure the similar behaviour of the fluctuation for both variables.

Figure 9. PSV 4,000 DWT Term Charter Rate Global and PSV 800 m2 5yo SHP

(January 2008 – January 2019)

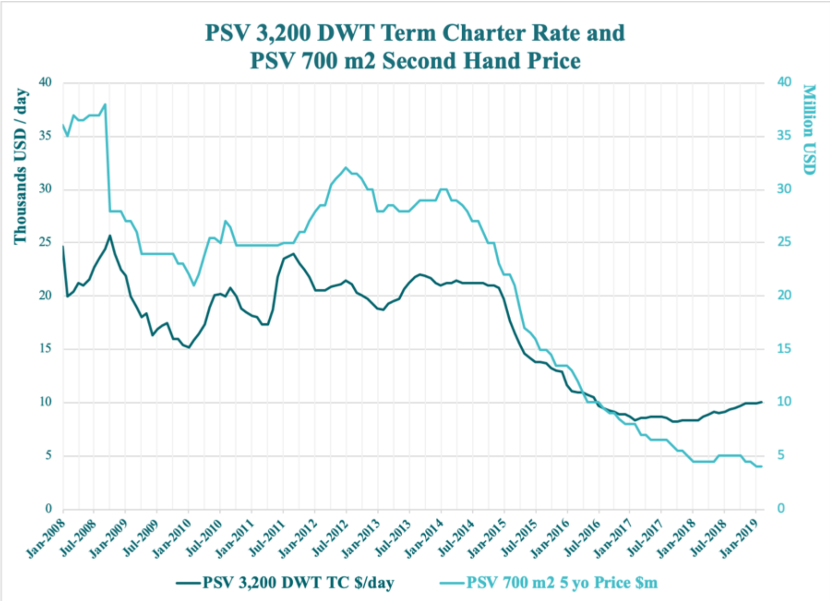


Note: Data retrieved from Clarksons OIN database circa July 2019

PSV 3,200 DWT – T/C Rate Global and PSV 700 m2 deck area - 5yo SHP (Figure 10); the deployment of these vessels is well balanced among all offshore regions. This type of PSV represents 28% of the market share and is also capable of performing supply duties and transport oil field cargo over long distances in harsh environments like Brazil and the North Sea (Clarksons Research Services, 2019).

Figure 10. **PSV 3,200 DWT T/C Rate Global and PSV 700 m² – 5yo – SHP**

(January 2008 – January 2019)



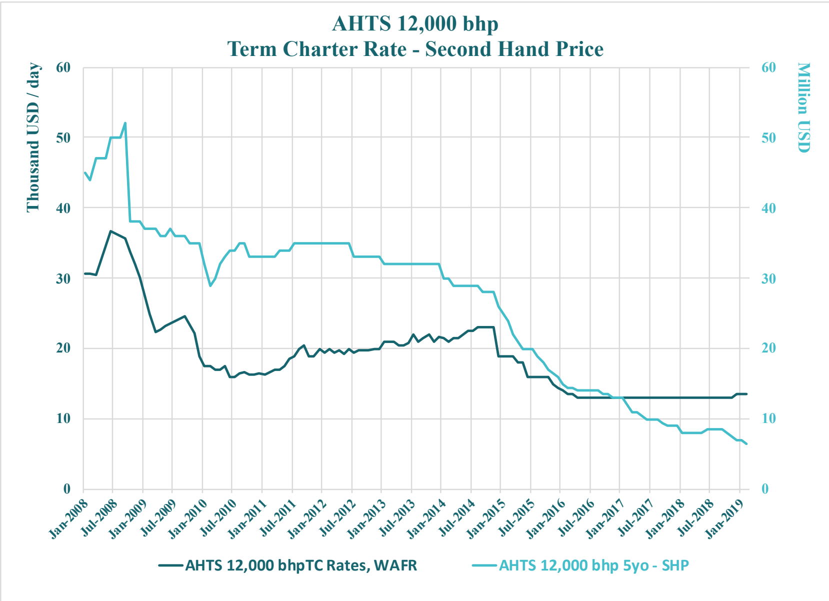
Note: Data retrieved from Clarksons OIN database circa July 2019

<u>AHTS 12,000 bhp – T/C Rate Global</u> and <u>AHTS 12,000 bhp – 5yo SHP (Figure 11)</u>; represents 15% of the AHTS market and are involved in supply operations as well as in towage of offshore units such as Jack-Up drilling rigs or production units. Deployment of units is spread throughout the main offshore regions and may excludes the deep-water regions of Brazil and the North Sea where larger vessels are required (Clarksons Research Services, 2019).

<u>*AHTS 7,000 bhp – T/C Rate Global - AHTS 80t BP – 5yo SHP* (Figure 12)</u>; most predominant vessels in the global AHTS market with 59% of market share, the operational region is mainly Middle East and South East Asia, performing supply, towing and anchor deployment duties (Clarksons Research Services, 2019).

Figure 11. AHTS 12,000 bhp WAFR and SHP

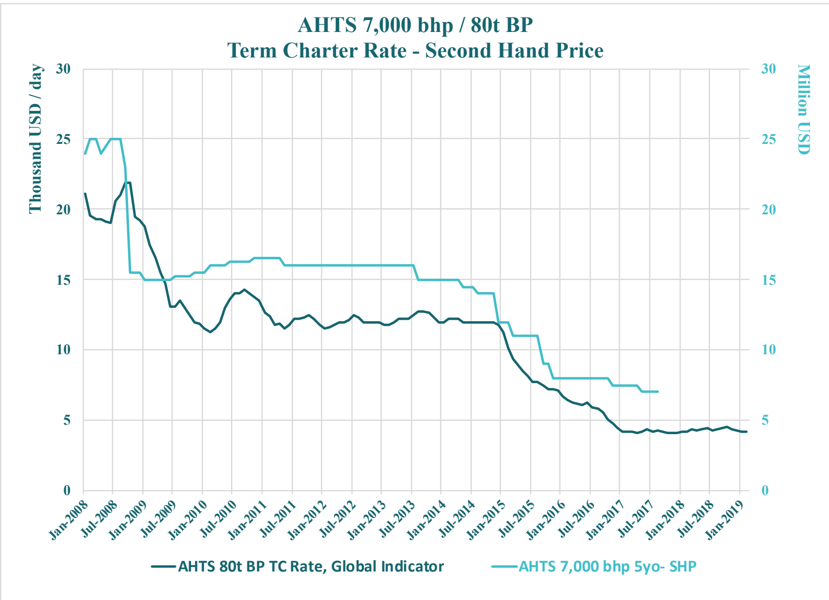
(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

Figure 12. **AHTS 7,000 bhp T/C Rate and AHTS 80t – SHP**

(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

Table 5 present the summary of the eight dependent variables and the codes assigned for the regression (OLS_Name). These dependent variables are also used as independent variables in the models where the specific variable is not examined, this as part of the investigation of the relationship of the variables within the industry and the significance between it.

Table 5. List of dependent variables (Name of Regressions)

Dependent Variables			
OLS_Name	**Description**	**OLS_Name**	**Description**
A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator - $/day	A2_PSV_SHP	PSV 800m² deck 5yo - SHP - $m
A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator - $/day	A4_PSV_2_SHP	PSV 700m2 deck 5yo - SHP - $m
A5_AHTS_TC	AHTS 12,000 bhp TC Rates, WAFR - $/day	A6_AHTS_SHP	AHTS 12,000 bhp 5yo - SHP - $m
A7_AHTS_2_TC	AHTS 80t BP TC Rate, Global Indicator - $/day	A8_AHTS_2_SHP	AHTS 7,000 bhp 5yo - SHP - $m

3.1.2. Independent Variables

The following are the independent variables selected for the model. The selection corresponds to the operational interrelation based on offshore O&G industry practices for two of the most intense cycles in terms of OSVs demand: exploration/development drilling and production. Some exogenous variables like Brent crude oil price or oil production were also considered, due to it being considered as the main drivers of the industry. Independent variables are underlined.

3.1.2.1. Global Economic Influential Factors

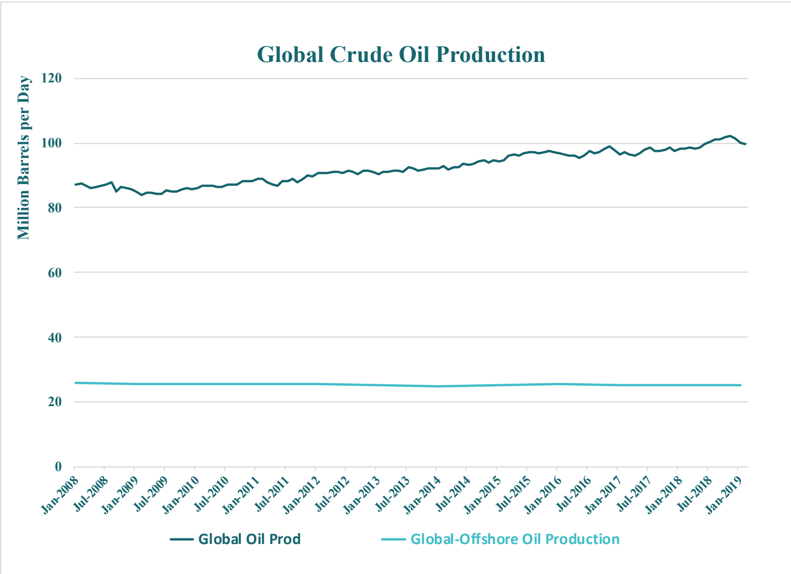
Brent Crude Oil Price (Figure 14): the historical fluctuating prices of Brent crude oil as an international benchmark, has been a primary determinant for oil producers whether to invest or not in exploration and development activities and therefore affecting directly the exploration and field development spending and derivate services such as oilrigs market (Ringlund, Rosendahl, & Skjerpen, 2008). As a derived demand from the offshore oil and gas E&P activity, since offshore shipping services depends on the necessity to transport oil field cargo to the offshore units

(Kavussanos & Alizadeh, 2001), it is expected that the demand for OSVs faces similar positive or negative consequences.

Global Oil Production (Figure 13): has been a determinant in the oil price fluctuation and has a derived influence in E&P activities. Over the years, the Organization of the Petroleum Exporting Countries[13] (OPEC) have strategically reduced oil production, leading to rises in the global oil price. The oil price increments also have an effect on the non-OPEC countries where the production for the short run is slightly inflexible. Nevertheless, at some point high prices influence non-OPEC countries to increase the supply (Ringlund, Rosendahl, & Skjerpen, 2008) and hence influence the price.

***Figure 13.* Crude Oil Production (Global & Offshore)**

(January 2008 – January 2019)



Data retrieved from Clarksons OIN database circa July 2019

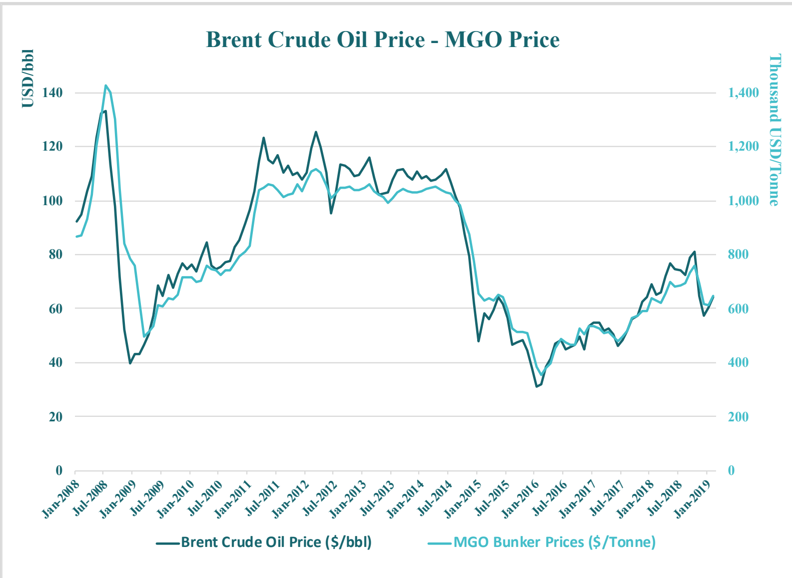
Marine Gas Oil (MGO) Bunker Price (Figure 14): as the majority of mobile drilling units, PSVs and AHTS use MGO; the bunker price becomes an essential factor for the economy of any offshore E&P project. MGO is comparatively the most

[13] OPEC COUNTRIES: Algeria, Angola, Dem. Rep. Congo, Ecuador, Equatorial Guinea, Gabon, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, United Arab Emirates and Venezuela (ENI SpA, 2019) .

expensive fuel utilized by vessels (Marine Bunker Exchange, 2019). For time charter party contracts, the international practice determines that the charterer provides and pay for all fuel (BIMCO, 2017), including drilling rigs. For example, according an oil company daily drilling reports for 2018, a sixth-generation ultradeep water drillship with 4 years of service and capable to drill in a water depth up to 12,000ft, consumed an average of 60 m3 per day under drilling operations, while a 7,000 bhp AHTS consumes between 17 m3 at economical speed and 22 – 30 m3 sailing at maximum speed (Tidewater Inc, 2019), and a PSV 4,000 DWT utilizes an average of 18 m3 per day while operating (Clarksons Research Services, 2019). This operational cost, which is affected by the sailing distance between the shore base and the drilling unit, is a crucial deciding factor of oil companies - whether the type of vessel to charter or the number of vessels to have per project.

***Figure 14*. Brent Crude Oil Price and Marine Gas Oil Price**

(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

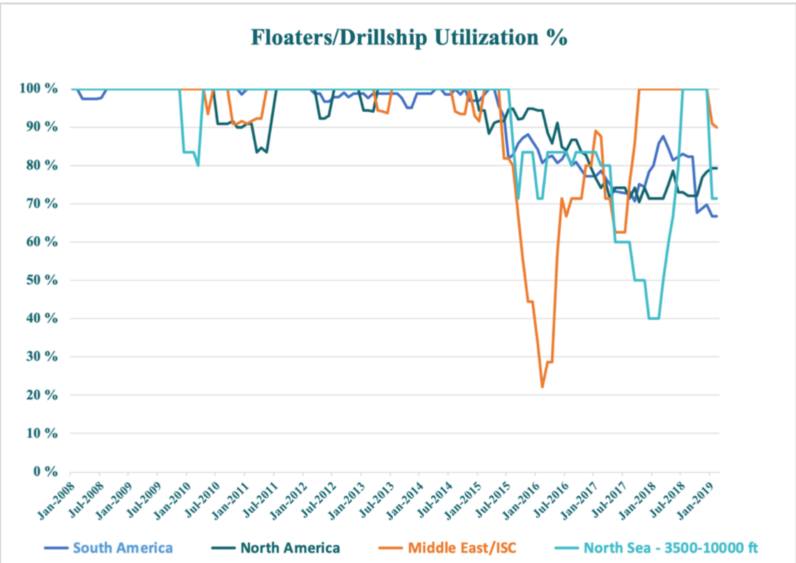
London Inter-Bank Offered Rate (LIBOR): shipping is a capital-intensive activity, and resource allocation is vital for shipping companies to finance their operations and make sale and purchase decisions. 3-month LIBOR indicates the finance cost in shipping, and have a substantial influence in the second-hand vessels price variation when high capital is required (Merika, Merikas, Tsionas, & Andrikopoulos, 2019).

3.1.2.2. Service Utilization Indicators/Factors

Utilization factor (Figure 15) as a supply and demand indicator, contributes by measuring the operational activity. This factor contains market information and is expected to positively influence the dayrate variation. For specific markets such as drilling rigs, the utilization factor reflects the increase or reduction of drilling operations, and hence an indication of the overall dynamics of the E&P industry (Clarksons Research Services, 2019b) .The service utilization variables are:

- Utilization - South America and Middle East/ISC Total No. of Floaters[14]
- Utilization - North America - Total Drillships
- Utilization - North Sea – 3,500-10,000 ft Floaters

Figure 15. **Floaters Utilization for the period (January 2008 – January 2019)**



Note: Data retrieved from Clarksons OIN database circa July 2019

[14] Floating Drilling Units; semi-submersibles and ship-shaped units "Drillships" (Clarksons Research Services, 2019).

3.1.2.3. Services Rates/International

The high homogeneity of the vessels regarding their capabilities and technical specification (Ådland et al., 2017), the number of options available worldwide, and the natural ability of the shipping companies to place the vessels in a required area after a short notice, makes the OSV market highly competitive. Rates are a direct indicator of the demand and supply of the OSV service in the market. The consideration of the two common types of rates (spot and term rates) bring valuable information to the model. Spot rates in the OSV market are particularly short. Usually, the spot term for an OSV fixture has a duration of less than 30 days (Ådland et al., 2017). On the other hand, term contract fixtures and rates reflect the movements of the market and provide information about projects that require more than 30 operational days. In other words, freight rates represent the "sensitivity of demand and supply to the changes in prices" (Shuo, 2018, p 127). The following are the selected variables of services rates for different types of OSV deployed in representative offshore regions (Figure 16):

- PSV 500-899m^2 Spot Rate - North Sea
- AHTS 18,000 bhp and 15,000 bhp T/C Rates - Brazil
- PSV 750-899m^2 T/C Rates - GoM
- AHTS 16-20,000 bhp Spot Rates N. Sea
- AHTS 12,000 bhp T/C Rates – S.E. Asia

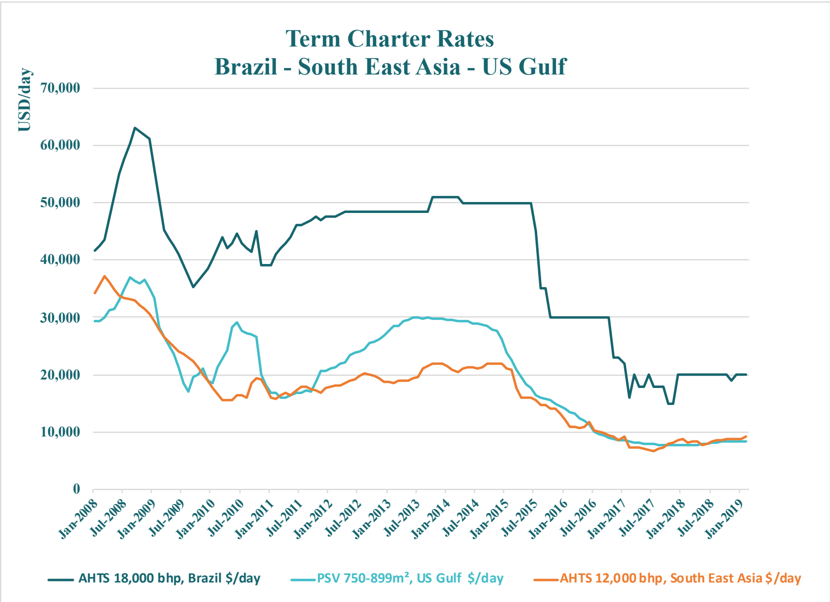
The variables for the segment of MODU for the model-built process are as follows (Figure 17):

- Global Avg. Jack-Up Dayrate, All and Index
- Global Avg. Floater Dayrate, Mid, Deep and Ultra Deep waters[15]
- Global Avg. Floater Dayrate, All

[15] Midwater (>=500 and <5,000ft), Deepwater (>=5,000ft and <7,500ft) and Ultra-deepwater (>=7,500ft) (Clarksons Research Services, 2019) .

Figure 16. **International Rates for OSV in different regions worldwide**

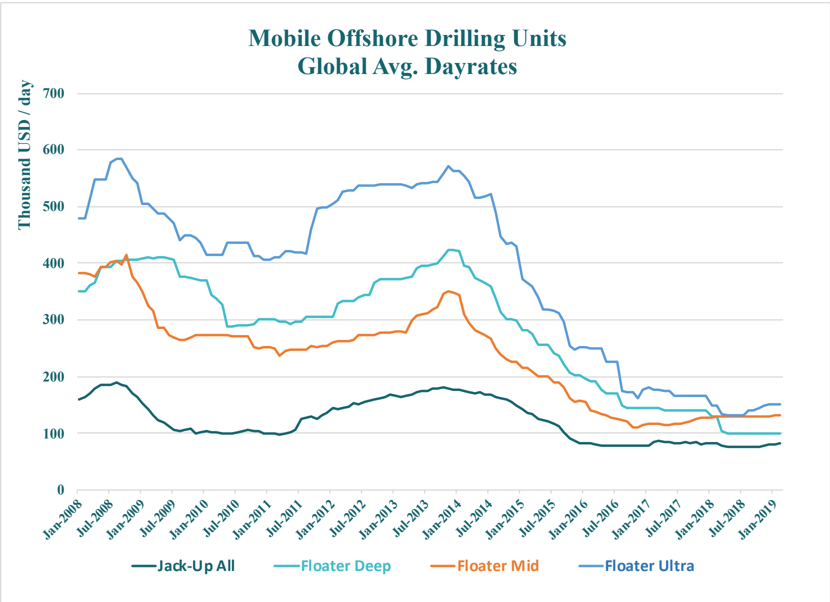
(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

Figure 17. International Rates for MODU

(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

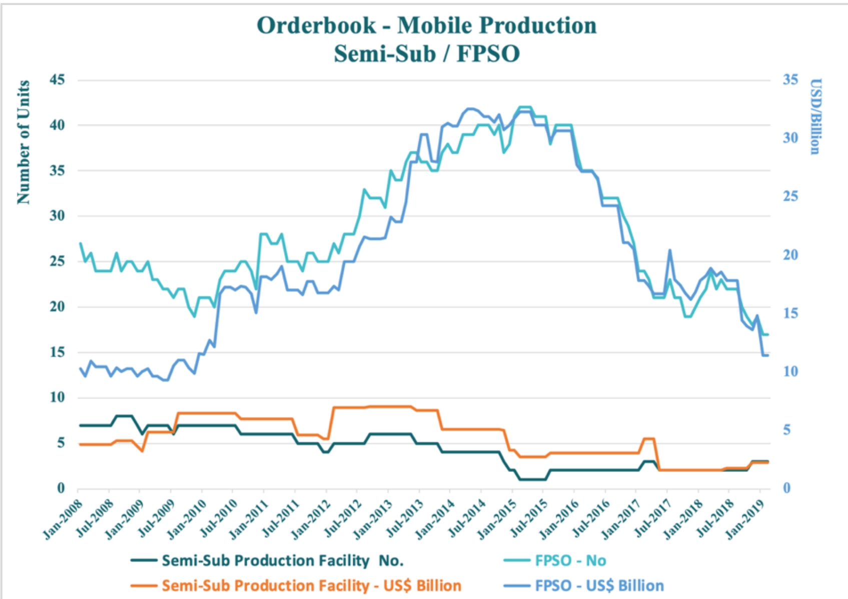
3.1.2.4. Services Orderbooks/International

Orderbook variables are included in order to identify cycles of the second-hand prices, because it is considered that new build orderbook negatively influence the second-hand prices (Tsolakis et al., 2003). Orderbook information from different types of units (Figure 18) assures the presence of the dynamic information of relevant segments of the operation into the model. The following are the estimated variables for the models:

- <u>Orderbook - PSV/Supply</u>
- <u>Orderbook - Mobile Production – SS Prod. Facility – No.</u>
- <u>Orderbook - Mobile Production - FPSO – No.</u>
- <u>Orderbook - Mobile Production - – SS Prod. Facility – USD Billion</u>
- <u>Orderbook - Mobile Production - FPSO – USD Billion</u>

***Figure 18.* Offshore Mobile Production Units Orderbook**

(January 2008 – January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

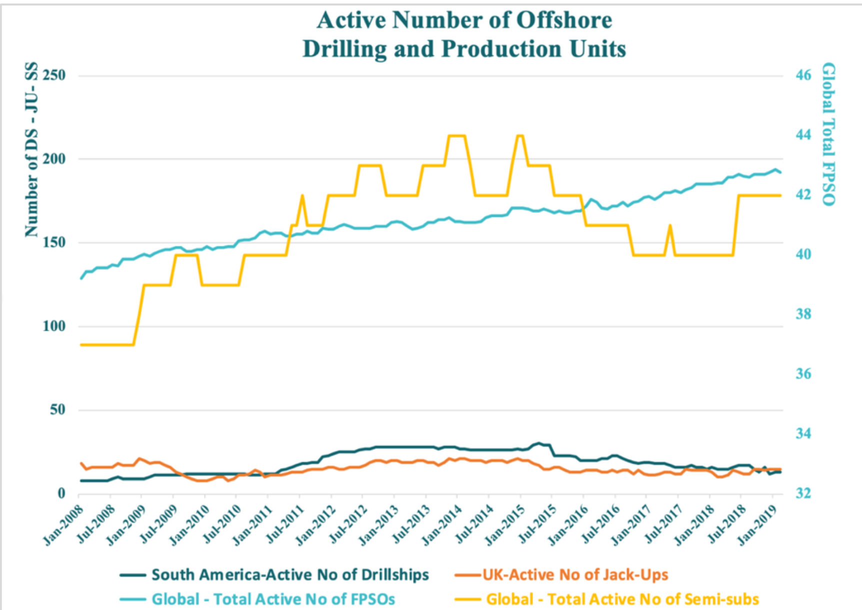
3.1.2.5. Active drilling and Production units/International

The rapid fluctuation of the number of active units in the market (Figure 19) provide fast information to the model[16]. The status for some inactive units can be shifted in a short time; this allows a fast reaction of the supply during eventual increments or reductions of the demand, representing a rapid market activation or deactivation according to the industry dynamics. The selected variables used in the models are as follows:

- UK - Active No. of Jack-Ups
- South America - Active No. of Floaters and No. of Drillships
- Global - Total Active No. of FPSOs and No. of Semi-subs
- Baker Hugues Total Active Rig Count

***Figure 19.* Active Number of Units (Drilling and Production)**

(January 2008 to January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

[16] Active status corresponds to the active units ready or under operation and hence a fast response to the market demand. Inactive units correspond to cold stack, laid up, idle, ready stacked/available units (Clarksons Research Services, 2019)

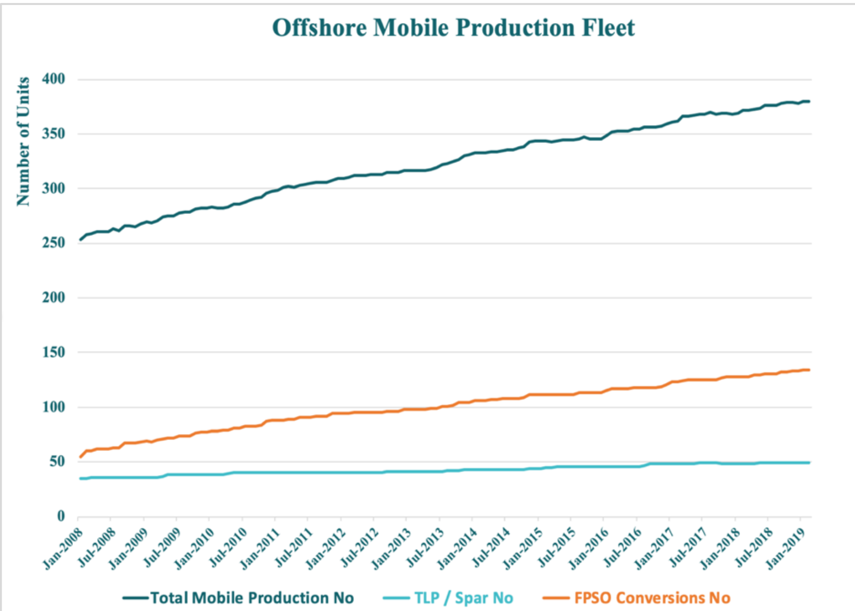
3.1.2.6. Production Fleet

Production fleet shown in Figure 20, represents all units including units under "Active" or "Inactive" status. These variables indicate the sensitivity of the status of the global offshore production market and collect information of the mobile oil production segment. The variables selected as follows:

- Fleet - Mobile Production
- Fleet - Mobile Production > TLP / Spar
- Fleet - FPSO Conversions

Figure 20. Offshore Mobile Production Fleet

(January 2008 to January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

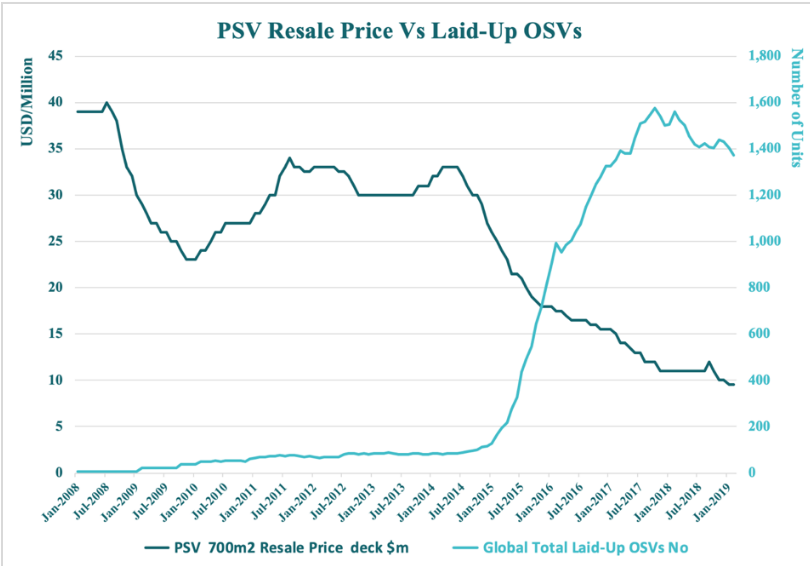
3.1.2.7. Other Factors

Resale price information (Figure 21) is of interest since this specific variable collects information from demand improvements and new builds negotiation prices. Laid-up vessels represent the first level of elasticity of the market. Eventually the market reabsorb the laid-up tonnage, this may hinder improvement in the demand and supply balance (Clarksons Research Services, 2019).

- PSV Resale Price Medium c 700m2 deck
- Laid-Up Vessels, Global: Total OSVs

Figure 21. **Resale Price – Laid-Up No of vessels**

(January 2008 to January 2019)



Note: Data retrieved from Clarksons OIN database circa July 2019

Offshore E&P activities and the type and number of interdependent processes and services associated with the operation are unique for each project, time, and region (Kaiser, 2010). Figure 22 summarizes the multiple operational factors discussed in this chapter. The total number of variables including the dependent variables is 43. Table 6 present the summary of the 35 independent variables identified for this research, and the nomenclature assigned to each variable for the model-building process.

Figure 22. **Offshore Oil - Overview and Segments**

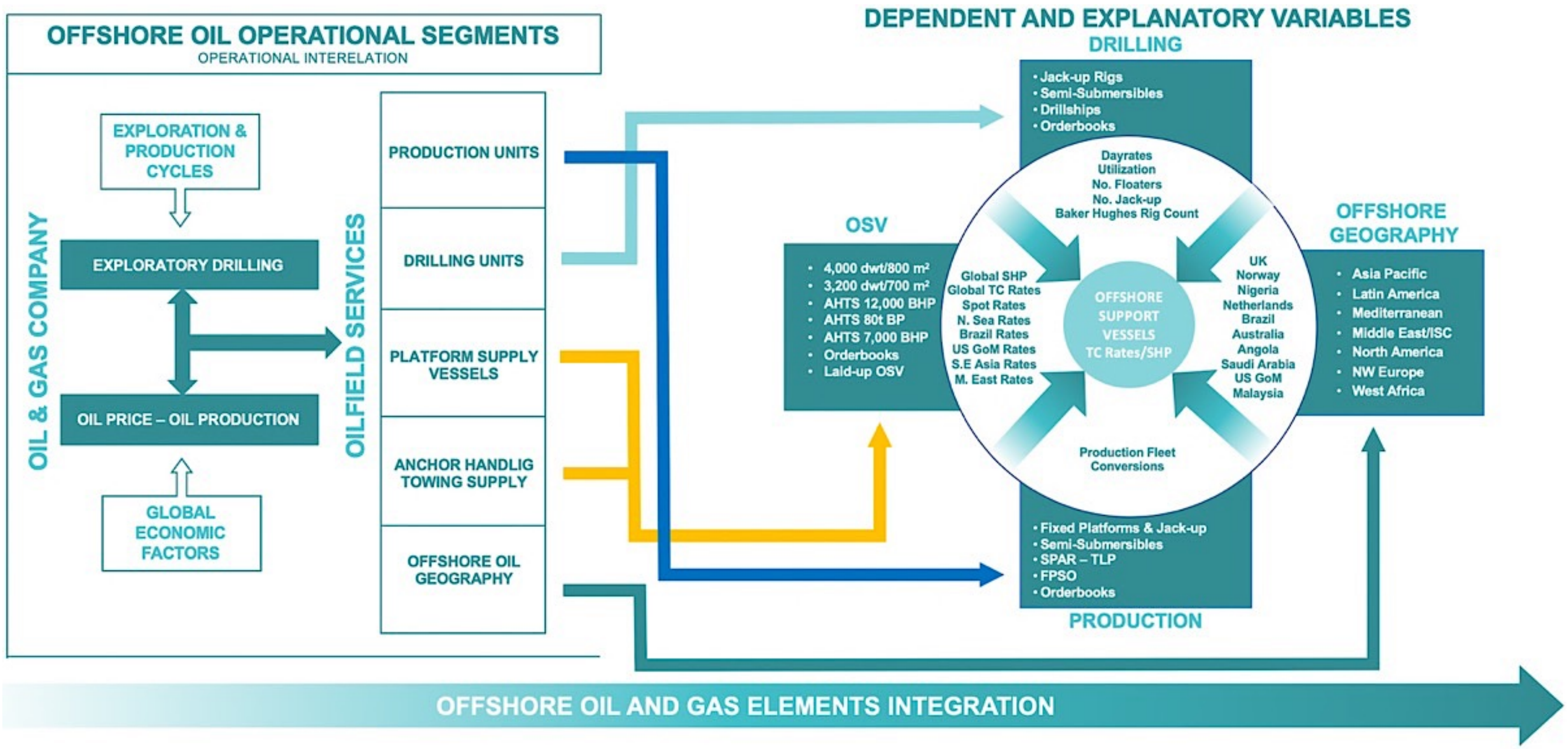


Table 6. List of independent variables for the models

Independent Variables			
OLS_ Name	**Description**	**OLS_ Name**	**Description**
General Driving Factors		**Services Orderbooks/International**	
AB_11	LIBOR Interest Rates	AB_15	PSV/Supply Orderbook
AB_12	Brent Crude Oil Price	AD_18	Orderbook > Mobile Production > SS Production Facility - No
AB_13	Global Oil Prod.	AD_19	Orderbook > Mobile Production > FPSO - No
AB_14	MGO Bunker Prices	AD_24	Orderbook > Mobile Production >SS Production Facility - US
Service Utilization Indicators/Factors		AD_25	Orderbook > Mobile Production > FPSO - US
AC_12	South America- Total Floaters Utilization	**Active drilling and Production units/International**	
AD_11	North America- Total Drillships Utilization	AC_16	South America-Active No of Floaters
AE_17	Middle East/ISC- Total Floaters Utilization	AD_10	South America-Active No of Drillships
AE_18	North Sea- 3,500-10,000 ft Utilization	AD_14	Global - Total Active No of FPSOs
Services Rates/International		AE_11	Global - Total Active No of Semi-subs
AC_11	PSV 500-899m^2 Spot Rate, North Sea	AE_20	UK-Active No of Jack-Ups
AC_14	AHTS 18,000 bhp TC Rate - Brazil,	AE_13	Baker Hugues Total Rig Count
AC_15	PSV 750-899m^2 TC Rate - US GOM	**Production Fleet/International**	
AF_10	AHTS 16-20,000 BHP Spot Rates - North Sea	AD_17	Fleet > Mobile Production
AF_11	AHTS 15,000 bhp TC Rate - Brazil	AD_22	Fleet > Mobile Production > TLP / Spar
AF_12	AHTS 12,000 bhp TC Rate - South East Asia	AD_27	Fleet > FPSO Conversions
AG_11	Global Avg Jack-Up Dayrate, All	**Other Factors**	
AG_12	Global Avg Floater Dayrate, Ultra	AD_15	PSV Resale Price Medium c 700m2 deck
AG_13	Global Avg Floater Dayrate, Deep	AE_10	Laid-Up Vessels, Global: Total OSVs
AG_14	Global Avg Floater Dayrate, Mid		
AG_15	Global Avg Floater Dayrate, All		

3.1.3. Descriptive Statistics of Variables

The Dataset comprises 116 monthly observations from January 2008 to August 2017 for the dependent variable AHTS 7,000 bhp 5yo SHP (A8_AHTS_2_SHP), and 134 monthly observations from January 2008 to February 2019 for all the other variables used for the structure of the regressions. The values presented in Table 7 and 8, indicate that T/C rate and SHP for PSVs 4,000 DWT and 800 m^2 deck area fluctuated more than the rest of selected vessels, and T/C and SHP for the AHTS 7,000 bhp / 80t Bollard Pull fluctuated the least. The Jarque and Bera (JB) test for normality (Bera & Jarque, 1981) showed departure from normality for the majority of the dependent and independent variables.

Table 7. Descriptive Statistics Dependent Variables

	T	Mean	Median	Maximum	Minimum	Std. Dev.	Skew.	Kurt.	J-B	Prob.
Group A: Dependent Variables										
A1_PSV_TC	134	23357.420	24911.250	44800.000	10800.000	8830.369	0.178	2.299	3.450	0.178
A2_PSV_SHP	134	31.757	35.000	68.000	8.500	13.649	0.290	3.330	2.482	0.289
A3_PSV_2_TC	134	16686.460	18625.000	25700.000	8250.000	5268.020	-0.416	1.695	13.379	0.001
A4_PSV_2_SHP	134	20.950	24.750	38.000	4.000	9.957	-0.433	1.907	10.854	0.004
A5_AHTS_TC	134	19085.710	19000.000	36691.790	13000.000	5822.747	1.185	4.234	39.869	0.000
A6_AHTS_SHP	134	26.556	32.000	52.000	6.500	11.831	-0.226	2.037	6.316	0.043
A7_AHTS_2_TC	134	10685.850	12000.000	21900.000	4100.000	4691.674	0.257	2.584	2.436	0.296
A8_AHTS_2_SHP	116	14.347	15.250	25.000	7.000	4.376	0.275	3.474	2.549	0.280

Table 8. Descriptive Statistics Independent Variables

	T	Mean	Median	Maximum	Minimum	Std. Dev.	Skew.	Kurt.	J-B	Prob.
Group B: Independent Variables										
AB_11	134	0.011	0.007	0.039	0.003	0.009	1.220	3.360	33.946	0.000
AB_12	134	80.609	76.470	133.207	30.981	27.120	0.050	1.650	10.226	0.006
AB_13	134	92.247	91.585	102.070	83.930	4.953	0.083	1.781	8.446	0.015
AB_14	134	796.225	745.000	1426.500	355.000	243.432	0.220	2.075	5.862	0.053
AB_15	134	934805.100	779474.500	1563946.000	433071.000	339038.000	0.417	1.845	11.334	0.003
AC_11	134	9246.588	7930.250	30983.600	2333.125	5425.188	1.334	4.908	60.063	0.000
AC_12	134	92.306	98.592	100.000	63.333	10.322	-1.086	2.793	26.589	0.000
AC_14	134	39637.750	43621.750	63000.000	15000.000	12584.040	-0.515	2.102	10.424	0.005
AC_15	134	20262.860	20825.000	36888.000	7700.000	8729.592	-0.059	1.762	8.634	0.013
AC_16	134	55.769	54.500	88.000	19.000	20.059	-0.050	1.749	8.790	0.012
AD_10	134	18.724	18.000	30.000	8.000	6.782	0.054	1.607	10.897	0.004
AD_11	134	91.909	94.737	100.000	70.370	10.066	-0.926	2.390	21.243	0.000
AD_14	134	162.933	162.000	194.000	129.000	15.391	0.059	2.393	2.132	0.344
AD_15	134	24.854	27.000	40.000	9.500	8.562	-0.322	1.943	8.547	0.014
AD_17	134	322.970	322.500	380.000	253.000	36.253	-0.158	1.870	7.691	0.021
AD_18	134	4.373	5.000	8.000	1.000	2.105	-0.013	1.562	11.542	0.003
AD_19	134	28.537	26.000	42.000	17.000	7.178	0.429	1.826	11.812	0.003
AD_22	134	42.567	41.500	49.000	35.000	4.284	0.070	1.766	8.609	0.014
AD_24	134	4.423	4.570	7.060	1.550	1.821	-0.061	1.728	9.117	0.010
AD_25	134	20.110	17.910	32.530	9.330	7.448	0.298	1.868	9.133	0.010
AD_27	134	100.388	101.000	134.000	55.000	21.000	-0.253	2.057	6.399	0.041
AE_10	134	452.373	83.000	1575.000	5.000	581.392	0.941	2.074	24.566	0.000
AE_10	134	452.373	83.000	1575.000	5.000	581.392	0.941	2.074	24.566	0.000
AE_11	134	40.851	41.000	44.000	37.000	1.796	-0.455	2.681	5.198	0.074
AE_13	134	2789.560	2997.500	3900.000	1405.000	710.756	-0.260	1.605	12.380	0.002
AE_17	134	91.757	100.000	100.000	22.222	16.370	-2.469	8.852	327.414	0.000
AE_18	134	91.414	100.000	100.000	40.000	15.187	-1.820	5.533	109.809	0.000
AE_20	134	15.134	15.000	21.000	8.000	3.490	-0.034	2.090	4.651	0.098
AF_10	134	17885.490	14961.380	51443.800	4559.250	10456.560	0.954	3.457	21.472	0.000
AF_11	134	33556.380	36709.960	60133.560	13000.000	11445.940	-0.072	2.228	3.442	0.179
AF_12	134	17608.940	17881.100	37216.580	6732.000	7369.753	0.591	3.078	7.830	0.020
AG_11	134	123.307	112.339	189.135	76.167	37.760	0.248	1.531	13.425	0.001
AG_12	134	386.381	435.125	585.000	133.000	151.763	-0.489	1.697	14.808	0.001
AG_13	134	282.848	301.250	424.000	99.000	105.506	-0.469	1.805	12.885	0.002
AG_14	134	235.932	253.286	415.000	110.357	84.601	0.060	2.076	4.848	0.089
AG_15	134	290.238	320.667	445.679	122.059	105.723	-0.399	1.711	12.821	0.002

3.2 Methodology

This section presents the econometric methods and the process used to build adequate empirical OLS ARMA GARCH models, the model should possess the right theoretical analysis and be able to explain the examined dependent variables. Variables names are in *italics.*

> It is important to note that the process of building a robust empirical model is an iterative one, and it is certainly not an exact science. Often, the final preferred model could be very different from the one originally proposed, and need not be unique in the sense that another researcher with the same data and the same initial theory could arrive at a different final specification. (Brooks, 2014, p 12)

3.2.1. Stationarity

Determining the stationarity of the variables is crucial before building each model. The stationarity level of the variables can impact the properties and performance of the model. The Unit Root Test is used to determine the stationarity of each of the selected variables. The test is conducted by the application of the Augmented Dickey and Fuller (1981) (ADF), Phillips and Perron (1988) (PP). Discrepancies between PP and ADF tests are validated using the Kwiatkowski, Phillips, Schmidt, and Shin (1992) (KPSS) stationarity robustness test. The results of this test confirm if the variables are stationary at first difference or in level.

Table 9 presents the unit root test for the dependent variables of the regressions, which correspond to global term charter rate and second-hand price for *PSV 4,000 DWT/800m2 deck area* and *PSV 3,200 DWT/700m2 deck area*, and T/C Rate and SHP for *AHTS 12,000 bhp* and *7,000 bhp/80t BP*. The test reports that all the dependent variables are stationary in first difference. KPSS test was not required due to the consistency in PP and ADF results. Table 10 shows the result of PP and ADF tests for the 35 selected independent variables. All the variables were found as stationary in first difference except *PSV 500-899m² Spot Rate in the North Sea* (AC_11), and *AHTS 16-20,000 bhp - Spot Day Rates in the North Sea* (AF_10). KPSS test was conducted for *Fleet > FPSO Conversions* (AD_27) as it presented discrepancy between PP and ADF tests. The result of the KPSS test showed stationarity of the variable in the first difference.

Table 9. Unit Root Test for dependent variables.

Critical Value for ADF & PP: -2.88 / KPSS 0.463

	ADF			PP			KPSS			
	Level	I (1)	I(2)	Level	I (1)	I(2)	Level	I (1)	I(2)	CONCLUSION
Group A: Dependent Variables										
A1_PSV_TC	-1.678	-7.528	-	-1.678	-7.528	-	-	-	-	I(1)
A2_PSV_SHP	-0.734	-9.721	-	-0.954	-9.750	-	-	-	-	I(1)
A3_PSV_2_TC	-0.757	-9.159	-	-1.367	-9.326	-	-	-	-	I(1)
A4_PSV_2_SHP	-0.790	-5.317	-	-0.535	-11.235	-	-	-	-	I(1)
A5_AHTS_TC	-1.930	-7.696	-	-1.865	-7.719	-	-	-	-	I(1)
A6_AHTS_SHP	-0.431	-12.176	-	-0.438	-12.208	-	-	-	-	I(1)
A7_AHTS_2_TC	-1.159	-7.799	-	-1.764	-7.993	-	-	-	-	I(1)
A8_AHTS_2_SHP	-1.527	-9.045		-1.527	-9.035	-	-	-	-	I(1)

Table 10. Unit Root Test for independent variables

	ADF			PP			KPSS			
	Level	I (1)	I(2)	Level	I (1)	I(2)	Level	I (1)	I(2)	CONCLUSION
Group B: Independent Variables										
AB_11	-1.971	-5.593	-	-2.541	-10.096	-	-		-	I(1)
AB_12	-2.358	-7.068	-	-1.919	-6.752	-	-	-	-	I(1)
AB_13	-0.420	-13.509	-	-0.314	-13.530	-	-	-	-	I(1)
AB_14	-2.576	-5.584	-	-1.891	-5.483	-	-	-	-	I(1)
AB_15	-0.647	-3.733	-	-0.472	-10.261	-	-	-	-	I(1)
AC_11	-4.467	-12.945	-	-4.543	-13.696	-	-	-	-	Level
AC_12	0.322	-11.038	-	0.499	-11.026	-	-	-	-	I(1)
AC_14	-0.295	-8.803	-	-0.941	-9.181	-	-	-	-	I(1)
AC_15	-1.259	-6.703	-	-1.216	-6.987	-	-	-	-	I(1)
AC_16	0.447	-9.391	-	0.080	-9.598	-	-	-	-	I(1)
AD_10	-1.396	-11.578	-	-1.426	-11.609	-	-	-	-	I(1)
AD_11	-1.315	-11.965	-	-1.145	-12.191	-	-	-	-	I(1)
AD_14	-1.158	-12.516	-	-1.223	-13.480	-	-	-	-	I(1)
AD_15	-1.116	-4.199	-	-0.796	-7.405	-	-	-	-	I(1)
AD_17	-1.802	-12.518	-	-1.802	-12.538	-	-	-	-	I(1)
AD_18	-1.329	-11.471	-	-1.300	-11.496	-	-	-	-	I(1)
AD_19	-0.611	-12.732	-	-0.601	-12.671	-	-	-	-	I(1)
AD_22	-0.939	-10.268	-	-0.938	-10.224	-	-	-	-	I(1)
AD_24	-1.305	-11.552	-	-1.243	-11.581	-	-	-	-	I(1)
AD_25	-1.030	-12.046	-	-1.108	-12.069	-	-	-	-	I(1)
AD_27	-2.400	-14.612	-	-3.151	-15.315	-	1.430	0.577	-	I(1)
AE_10	-0.721	-2.887	-	0.163	-5.945	-			-	I(1)
AE_11	-2.200	-11.062	-	-2.182	-11.084	-	-	-	-	I(1)
AE_13	-2.241	-3.294	-	-1.558	-5.314	-	-	-	-	I(1)
AE_17	-2.730	-8.925	-	-1.895	-8.823	-	-	-	-	I(1)
AE_18	-1.767	-10.034	-	-2.267	-10.089	-	-	-	-	I(1)
AE_20	-2.145	-11.434	-	-2.231	-11.468	-	-	-	-	I(1)
AF_10	-7.834	-11.054	-	-7.872	-24.170	-	-	-	-	Level
AF_11	-1.211	-7.121	-	-1.219	-7.092	-	-	-	-	I(1)
AF_12	-2.619	-7.702	-	-2.001	-7.701	-	-	-	-	I(1)
AG_11	-1.877	-4.191	-	-1.288	-6.928	-	-	-	-	I(1)
AG_12	-0.063	-8.318	-	-0.163	-8.505	-	-	-	-	I(1)
AG_13	0.280	-8.340	-	0.042	-8.845	-	-	-	-	I(1)
AG_14	-1.463	-5.040	-	-1.339	-8.812	-	-	-	-	I(1)
AG_15	-0.205	-7.419	-	-0.331	-7.779	-	-	-	-	I(1)

3.2.2. Correlation Test

After the identification of the stationarity level of the variables, the correlation test is performed between the independent variables in level or first difference in order to detect any correlation above 80% and hence avoid further issues caused by disregarding multicollinearity problems in the model. Bypassing the correlation between independent variables may cause the model to: first, have unsuitable outputs for the significance tests, leading to inappropriate conclusions, second, have a very sensitive model, were the removal or inclusion of any variable will make the coefficients of the regression to change considerably, and third, the variables individually will not have an appropriate contribution to the overall fit of the model (Brooks, 2014). The variables with correlation above 80% are subject to a theoretical and market analysis and are excluded from the regressions.

The correlation test reported that only two independent variables: Global Average Dayrate for Floaters All (AG_15) and Global Average Dayrate for Ultra-Deepwater Floaters (AG_12) presented correlation above 80% (Appendix 2). The latter variable was kept in the model due to its content of specific information of regions of interest such as ultradeep waters in GoM, Brazil, West Africa, and the North Sea, since the deployment of these drilling units is mostly in deep and ultra-deep water.

3.2.3. T – Test

The T-Test is performed to identify the explanatory variables affecting the dependent variable at a 5% significance level using Classical Linear Regression Model (CLRM). The form of the general regression to describe the relation of the dependent variables with the independent variables is as follows:

$$y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t,\ t=1,2,.....,T$$

Where y is the dependent variable, x_{1t}, x_{2t},…x_{kt} are the independent variables, α the intercept[17], β the coefficients and u_t is the error variable. The hypothesis for the test is $H_0: \beta_k = 0$. By rejecting the null hypothesis, it can be determined that the examined variable is significant, and thus affecting the dependent variable. In other words, the independent variable can explain variations in the dependent variable of the model.

Tables 11 to 16 present the results of the evaluation of the variables at 5% of significance level. These results and set of variables are used as the base OLS model to test as part of the building process of the ARMA GARCH, which is the expected model to be used in this research.

Table 11. Regressions PSV 4,000 dwt T/C Rate and 800m² deck 5yo - SHP

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		0.000	0.978
Significant Independent Variables			
D_LOG_AB_14	MGO Bunker Price	-2.755	0.007
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	8.237	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	2.993	0.003
D_LOG_AD_11	North America- Total Drillships Utilizatio	-1.956	0.053
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	2.074	0.040
D_LOG_AD_27	Fleet > FPSO Conversions	2.236	0.027
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	3.246	0.002

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck		
C		0.002	0.466
Significant Independent Variables			
D_LOG_AB_14	MGO Bunker Price	0.135	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.318	0.000
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.331	0.000
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.387	0.000
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.225	0.020
D_LOG_AD_17	Fleet > Mobile Production	-1.481	0.014
D_LOG_AD_22	Fleet > Mobile Production > TLP / Spar	0.836	0.008
D_LOG_AE_18	North Sea- 3500-10000 ft Utilization	-0.097	0.007
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.278	0.000
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	0.175	0.019
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	-0.192	0.034

[17] Intercept coefficient: can be interpreted as the average value which y would take if all the explanatory variables took a value of zero (Brooks, 2014).

Table 12. Regression PSV 3,200 dwt TC Rate

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator		
C		0.010	0.000
Significant Independent Variables			
D_LOG_AC_18	AHTS Term Charter Rates, WAFR, 12,00	0.171	0.002
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.347	0.000
D_LOG_AD_11	North America- Total Drillships Utilizatio	0.172	0.013
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.186	0.016
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.169	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	-0.228	0.001
D_LOG_AD_25	Orderbook > Mobile Production > FPSO	0.151	0.001
D_LOG_AD_27	Fleet > FPSO Conversions	-1.020	0.000
D_LOG_AE_10	Laid-Up Vessels, Global: Total OSVs	-0.041	0.009
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.452	0.000
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	-0.213	0.002
D_LOG_AG_12	Global Avg Floater Dayrate, Ultra	0.130	0.008

Table 13. Regression PSV 700m2 deck 5yo - SHP

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A4_PSV_2_SHI	PSV 5yo Price Medium c 700m2 deck		
C		-0.092	0.031
Significant Independent Variables			
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.519	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.420	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Su	-0.106	0.000
D_LOG_AC_14	AHTS Term Charter Rates Brazil, 18,000 b	-0.138	0.001
D_LOG_AD_24	Orderbook > Mobile Production > Semi-Su	0.089	0.001
D_LOG_AE_17	Middle East/ISC- Total Floaters Utilization	-0.068	0.008
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.176	0.031
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.010	0.035
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia	-0.118	0.039
D_LOG_AC_15	PSV Term Charter Rates, US Gulf, 750-89(	0.097	0.047
D_LOG_AB_13	Global Oil Prod.	0.620	0.054

Table 14. Regression AHTS 12,000 bhp T/C Rate

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.175	0.001
Significant Independent Variables			
D_LOG_AB_14	MGO Bunker Price	0.227	0.000
D_LOG_AC_16	South America-Active No of Floaters	-0.262	0.001
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.019	0.001
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.099	0.006
D_LOG_AB_15	PSV/Supply Orderbook	0.222	0.010

Table 15. Regression AHTS 12,000 bhp 5yo - SHP

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A6_AHTS_SHP	AHTS 5yo, Medium 12,000 bhp		
C		-0.137	0.194
Significant Independent Variables			
D_LOG_AB_14	Brent Crude Oil Price	0.204	0.059
D_LOG_AC_16	Global Oil Prod.	0.014	0.003
LOG_AC_11	PSV 5yo Price Medium c 700m2 deck	0.014	0.000
D_LOG_AE_20	PSV 5yo Price Medium c 800m2 deck	0.011	0.002
D_LOG_AB_15	Middle East/ISC- Total Floaters Utilization	-0.038	0.047
D_LOG_AE_18	North Sea- 3500-10000 ft Utilization	0.081	0.014

Table 16. Regressions AHTS 80t BP TC Rat and AHTS 7,000 bhp 5yo - SHP

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2_T	AHTS 80t BP TC Rate, Global Indicator		
C		-0.105	0.004
Significant Independent Variables			
D_LOG_AD_17	Fleet > Mobile Production	2.018	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.143	0.000
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	0.226	0.001
D_LOG_AD_10	South America-Active No of Drillships	-0.144	0.002
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.176	0.002
D_LOG_AE_20	UK-Active No of Jack-Ups	0.065	0.004
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.010	0.010
D_LOG_AC_16	South America-Active No of Floaters	0.178	0.013
D_LOG_AB_14	MGO Bunker Price	0.072	0.014
D_LOG_AD_18	Orderbook > Mobile Production > Semi-S	0.036	0.017
D_LOG_AB_15	PSV/Supply Orderbook	-0.126	0.017
D_LOG_AB_11	LIBOR Interest Rates	0.048	0.021
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.138	0.025
D_LOG_AF_12	AHTS Term Charter Rates, South East As	0.094	0.031
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.142	0.039

Variable Name	Description	Coefficient	Prob.
Dependent Variable			
D_LOG_A8_AHTS_2_S	AHTS 5yo, Medium 7,000 bhp		
C		0.127	0.013
Significant Independent Variables			
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.422	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.328	0.002
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.355	0.009
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.207	0.010
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	-0.014	0.012

3.2.4. F – Test

To confirm the significance of the variables after the T-Test, a joint test with the insignificant variables where the coefficients are restricted and the null hypothesis *H0:* $\beta = 0$ is performed. The Wald test is conducted to verify the non-significance of the independent variables. Accepting the null hypothesis confirms to drop the variables, and hence it can be concluded that the tested regressors together are not explaining the dependent variable. Table 17 presents the summary of the test. Detailed results of the F-test for all the models can be found in Appendix 3.

Table 17. Summary of Wald Test Results

	F-statistic				F-statistic		
Variable Name	Value	df	Prob.	Variable Name	Value	df	Prob.
D_LOG_A1_PSV_TC	0.689	(34, 91)	0.889	D_Log_A5_AHTS_TC	0.693	(36, 91)	0.891
D_Log_A2_PSV_SHP	0.605	(30, 91)	0.940	D_Log_A6_AHTS_SHP	1.048	(35, 91)	0.417
D_Log_A3_PSV_2_TC	0.456	(29, 91)	0.991	D_Log_A7_AHTS_2_TC	0.841	(25, 91)	0.680
D_Log_A4_PSV_2_SHP	0.647	(30, 91)	0.911	D_Log_A8_AHTS_2_SHP	1.490	(37, 72)	0.074

3.2.5. Cointegration

The cointegration test is performed to determine the existence of a long-term relationship between the dependent and the independent variables. First, the residuals obtained from running individual regressions between the dependent and each of the independent variables (previously found as stationary at first difference level) are saved as Error Correction Terms (ECT). The ECTs that are stationary in level after the PP and ADF tests are included in the regression using the notation ECT(-1) in order to determine its significance and coefficient and attempt to have an error correction model. The ECT must follow the parameter of cointegration, which means that the ECT must be significant at 5% and have a negative coefficient.

Table 18 presents the results of the cointegration test for Global T/C rates and SHP for PSV 4,000 DWT, PSV 800m^2 deck area, and AHTS 12,000 bhp 5yo- SHP. All the ECTs included in the regressions (Appendix 4) appeared to be non-significant or with positive coefficient and were therefore discarded from the models.

Table 18. ECT PSV 4,000 dwt T/C Rates/SHP and AHTS 12,000 bhp SHP

Var. Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A1_PSV_TC		
Error Correction Terms		
ECT_AB14(-1)	-0.527	0.785
ECT_AC17(-1)	0.197	0.100
ECT_AC21(-1)	-0.177	0.132
ECT_AD11(-1)	0.195	0.737
ECT_AD16(-1)	0.920	0.031
ECT_AD27(-1)	-0.691	0.729
ECT_AG11(-1)	0.131	0.397

Var. Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A2_PSV_SHP		
Error Correction Terms		
ECT_AB14(-1)	0.335	0.092
ECT_AC22(-1)	0.008	0.938
ECT_AD10(-1)	-0.791	0.364
ECT_AE13(-1)	0.296	0.751
ECT_AE21(-1)	0.147	0.721
ECT_AG13(-1)	0.069	0.812

Var. Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A6_AHTS_SHP		
Error Correction Terms		
ECT_AB12(-1)	-0.226	0.263
ECT_AB13(-1)	0.633	0.003
ECT_AC22(-1)	-0.068	0.580
ECT_AD16(-1)	-0.112	0.372
ECT_AE17(-1)	-0.031	0.917
ECT_AE18(-1)	-0.293	0.217
Note: Result after dropping non-significant ECT;		
ECT_AE18(-1)	-0.038	0.499

3.2.6. ARMA process

The inclusion and combination of Autoregressive (AR) and Moving Average (MA) process in the regression make a more parsimonious model, which is a model able to explain the characteristics of the data by the usage of fewer parameters and to capture fundamental tendencies or patterns (Brooks, 2014).

To estimate the AR(*p*) and MA(*q*) lags it was necessary to start with the inclusion of ARMA terms from 1 to 5 to the equation: $y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t + ARMA(p,q)$ and drop variables one by one until getting significant ARMA terms in the model.

AR(*p*) and MA(*q*) terms were included in all the regressions to get combined ARMA(*p,q*) process in the regressions (Table 19). As a result of this step, all the models accepted at least ARMA(1,1) process, except the model Global T/C Rate for PSV 3,200 DWT which only MA(1) process was significant. Table 20 presents the result and the value for T/C rate for AHTS 12,000 bhp. More extensive results for all the regressions are included the Appendix 5.

Table 19. Summary of ARMA Terms Included in the regressions

OLS_ Name	Description	ARMA (*p,q*)
A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator	(1,2)
A2_PSV_SHP	PSV 800m2 deck 5yo - SHP	(2,2)
A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator	(0,1)
A4_PSV_2_SHP	PSV 700m2 deck 5yo - SHP	(2,2)
A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp	(2,2)
A6_AHTS_SHP	AHTS12,000 bhp 5yo - SHP	(2,2)
A7_AHTS_2_TC	AHTS 80t BP TC Rate, Global Indicator	(1,1)
A8_AHTS_2_SHP	AHTS 7,000 bhp 5yo - SHP	(1,1)

Table 20. ARMA terms included in AHTS 12,000 bhp T/C Rate

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.167	0.000
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.246	0.000
D_LOG_AB_15	PSV/Supply Orderbook	0.187	0.006
D_LOG_AC_16	South America-Active No of Floaters	-0.283	0.000
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.075	0.000
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.018	0.001
AR(1)		0.626	0.000
AR(2)		-0.911	0.000
MA(1)		-0.541	0.000
MA(2)		1.157	0.000

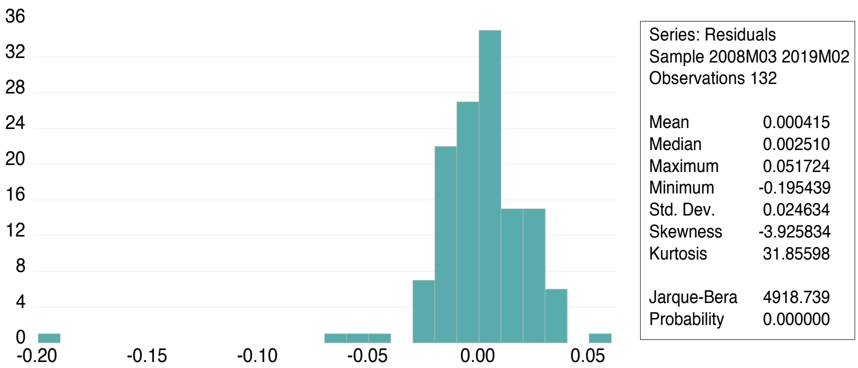
3.2.7. Jarque – Bera Test

The Jarque and Bera (1981) test is performed for each of the residuals of the ARMA model to observe its behaviour. The null hypothesis to test is that the residuals are normally distributed, and hence the rejection of the null hypothesis at the 5% level makes it necessary to examine the outliers of the residuals to determine the inclusion of dummy variables into the model. For some cases where the data set is large enough, the violation of the normality assumption has no virtual consequences (Brooks, 2014).

Some of the models, including those listed in Table 21, presented strong negatively skewed residuals, and a strong rejection of the null hypothesis, even after the inclusion of several dummy variables representing significant outliers. The non-normal distribution of the residuals seems to be caused by the cyclical nature of the market. All details on the JB test results for all regressions are included in Appendix 6.

Table 21. Jarque-Berra test results for: PSV 4,000 dwt T/C Rate - Global

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		-0.001	0.746
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	-0.115	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	1.040	0.000
D_LOG_AD_11	North America- Total Drillships Utilisation	-0.216	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	1.040	0.017
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	0.164	0.001
AR(1)		-0.514	0.000
MA(1)		0.869	0.000
MA(2)		-0.131	0.016



3.2.8. Heteroskedasticity (White Test) and Serial Correlation Test

As part of the base assumptions to build a model where the estimators are required to be Best Linear Unbiased Estimators (BLUE) it is necessary to detect patterns of heteroskedasticity in the models, meaning that the errors variance is not constant, and hence causing bias on the coefficients of the regressors (Brooks, 2014), and "as a result, faulty inferences will be drawn when testing statistical hypotheses in the presence of heteroskedasticity" (White, 1980, p 817). For the detection of the heteroskedasticity in the model the White (1980) test is used. The null hypothesis of this test is that the variance of the errors is constant $var\ (ut\ ) = \sigma 2 < \infty$ and hence the model is homoscedastic.

Another assumption of BLUE models refers to zero covariance amongst error terms, meaning that there is no serial correlation between errors. The test used to determine if the model presents serial correlation in this study is the Breush-Godfrey Lagrange Multiplier (LM) Test, which exams the autocorrelation of any order in the residuals (Brooks, 2014). The null hypothesis evaluated in this test is the non-existence of serial correlation and the number of lags to use is 14, due to the monthly frequency of the dataset. Once the White and LM tests are performed, the necessary correction has to be in place in order to handle the presence of heteroskedasticity, serial correlation or both in the models. Table 22 show the White or Newey-West (NW) corrections required as per the results of each of the tests. Table 23, summarizes the findings of the homoskedasticity and LM tests and show the respective White or NW corrections needed as per test results.

Table 22. Correction required from White – LM results

White Test	LM Test	Correction
Homoskedasticity	No Serial Correlation	No. Corr.
Heteroskedasticity	No Serial Correlation	White Corr.
Homoskedasticity	Serial Correlation	N-W Corr.
Heteroskedasticity	Serial Correlation	N-W Corr.

Table 23. Summary White – LM results

Variable Name	Description	White Test	LM Test	Correction
A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator	Homoskedasticity	No Serial Correlation	No. Corr.
A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck	Homoskedasticity	No Serial Correlation	No. Corr.
A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator	Heteroskedasticity	Serial Correlation	N-W Corr.
A4_PSV_2_SHP	PSV 5yo Price Medium c 700m2 deck	Homoskedasticity	No Serial Correlation	No. Corr.
A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp	Heteroskedasticity	Serial Correlation	N-W Corr.
A6_AHTS_SHP	AHTS 5yo, Medium 12,000 bhp	Homoskedasticity	No Serial Correlation	No. Corr.
A7_AHTS_2_TC	AHTS 80t BP TC Rate, Global Indicator	Heteroskedasticity	No Serial Correlation	White Corr.
A8_AHTS_2_SHP	AHTS 5yo, Medium 7,000 bhp	Heteroskedasticity	No Serial Correlation	White Corr.

The result of the White test for the regressions *PSV 4,000 dwt T/C Rate Global Indicator*, *PSVs 800m2 and 700m2 deck area 5yo – SHP,* and *AHTS 12,000 bhp 5yo – SHP* is that the models are homoskedastic and does not present serial correlation, hence no correction is necessary. The regressions *PSV 3,200 dwt T/C Rate - Global* and *AHTS 12,000 bhp T/C Rate World Average Freight Rete (WAFR),* rejected the null hypothesis of homoskedasticity and no serial correlation after the White and LM tests accordingly. As the models resulted in being heteroskedastic with serial correlation, NW correction was required.

For the regressions *AHTS 80t BP T/C Rate – Global* and *AHTS 7,000 bhp 5yo - SHP* the null hypothesis of homoskedasticity was rejected, and the null hypothesis of non-serial correlation in the model was accepted, hence for a heteroskedastic model with no serial correlation, the application of the White correction was required. Table 24, present the result of the tests for the regression of dependent variables *AHTS 80t BP T/C Rate – Global* and Table 25 shows the results for *AHTS 7,000 bhp 5yo - SHP*. For the complete results of the White and LM test see the Appendix 7.

Table 24. White and LM Test results for AHTS 80t BP T/C Rate

OLS_ Name - AHTS 80t BP TC Rate, Global Indicator			
Regression Code			
D_LOG_A7_AHTS_2_TC			
Heteroskedasticity (White-Test)			
F-statistic	3.392	Prob. F(119,12)	0.011
Obs*R-squared	128.189	Prob. Chi-Square(119)	0.266
Scaled explained SS	142.308	Prob. Chi-Square(119)	0.072
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	0.812969	Prob. F(14,104)	0.654
Obs*R-squared	13.02085	Prob. Chi-Square(14)	0.525

Table 25. White and LM Test results for AHTS 7,000 bhp 5yo - SHP

OLS_ Name - AHTS 7,000 bhp 5yo - SHP			
Regression Code			
D_LOG_A8_AHTS_2_SHP			
Heteroskedasticity (White-Test)			
F-statistic	2.332	Prob. F(44,69)	0.001
Obs*R-squared	68.163	Prob. Chi-Square(44)	0.011
Scaled explained SS	222.327	Prob. Chi-Square(44)	0.000
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	0.75734	Prob. F(14,92)	0.711
Obs*R-squared	11.78053	Prob. Chi-Square(14)	0.624

3.2.8.1. White / Newey West Corrections

Table 26 presents the final regression results for *AHTS 80t BP T/C Rate – Global* after the application of the White Test and NW test to the models according the test results. None of the significant variables for any regression was affected by the test and hence no variable was excluded from the models.

Table 26. Regression after White and N-W corrections

White Correction

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2_T	AHTS 80t BP TC Rate, Global Indicator		
C		-0.131	0.000
Significant Independet Variables			
D_LOG_AB_11	LIBOR Interest Rates	0.050	0.053
D_LOG_AC_16	South America-Active No of Floaters	0.169	0.009
D_LOG_AD_10	South America-Active No of Drillships	-0.154	0.000
D_LOG_AD_17	Fleet > Mobile Production	1.744	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Subme	0.057	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.100	0.002
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.244	0.000
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12	0.145	0.000
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.166	0.000
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.247	0.005
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.013	0.001
AR(1)		-0.472	0.004
MA(1)		0.852	0.000

3.2.9. Linearity Test

The linearity of the model is tested using the Regression Specification Error Test (Ramsey, 1969). The rejection of the null hypothesis comes when the test statistic values are above the X^2 critical value, and hence the model is not linear (Brooks, 2014). To address the linearity issue in this study a GARCH model is used. Table 27 present the summary of the test for all the regressions. The complete results of the linearity test are included in the Appendix 8.

Table 27. Ramsey RESET Test Results - Summary

	F-statistic		
Model Name	Value	df	Prob.
D_Log_A1_PSV_TC	22.230	(2, 121)	0.000
D_Log_A2_PSV_SHP	5.899	(2, 117)	0.004
D_Log_A3_PSV_2_TC	0.195	(2, 121)	0.823
D_Log_A4_PSV_2_SHP	0.245	(2, 115)	0.783
D_Log_A5_AHTS_TC	35.034	(2, 119)	0.000
D_Log_A6_AHTS_SHP	5.463	(2, 119)	0.005
D_Log_A7_AHTS_2_TC	0.069	(2, 116)	0.933
D_Log_A8_AHTS_2_SHP	15.677	(2, 104)	0.000

3.2.10. GARCH Model

To better capture underlying features of the data such as the volatility leverage, or model and forecast volatility, the GARCH estimation introduced by Bollerslev (1986) is contemplated for this study. GARCH is also one of the most popular non-linear models used for this purpose and widely employed and accepted. This model is described as superior to ARMA models because it prevents overfitting and has more parsimony (Brooks, 2014).

Final ARMA GARCH Equations:

Main Equation

$$y_t = \alpha + \beta_1 x_{1t} + \beta_2 x_{2t} + \cdots + \beta_k x_{kt} + u_t$$

Variance Equation

$$\sigma^2_t = \alpha_0 + \alpha_1 u^2_{t-1} + \beta\sigma^2_{t-1} + \gamma\, u^2_{t-1}\, I_{t-1}$$

where $I_{t-1} = 1$ if $u_{t-1} < 0$, and $I_{t-1} = 0$ if $u_{t-1} > 0$

α= lagged squared residual - ARCH term
β= lagged conditional variance - GARCH(-1) term
ɣ= asymmetry term

The following are the final OLS ARMA GARCH models built for PSV T/C rates and second-hand price and AHTS vessels T/C rates and SHP. The final equations are as follows:

PLATFORM SUPPLY VESSELS TC RATE AND SECOND HAND PRICE

A1_PSV 4,000 dwt TC Rate – Global Indicator - $/day

$y_{t\,A1} = -0.000 + 0.860 * AC\_17 – 0.067 * AD\_11$ (1)

$\sigma^2_{tA1} = 8.57E\text{-}06 + 0.157 * \alpha + 0.654 * \beta + 0.729 * \gamma$ (2)

A2_PSV 800m² deck 5yo – SHP - $m

$y_{tA2} = 0.0039 + 0.065 * AB\_14 - 0.291 * AC\_17 + 0.422 * AC\_19 + 0.426 * AC\_22 + 0.895\ AD\_17 + 0.285\ AE\_21$ (3)

$\sigma^2_{tA2} = 0.000605 + 0.754 * \alpha -0.171 * \beta - 0.555 * \gamma$ (4)

A3_PSV 3,200 dwt TC Rate, Global Indicator - $/day

$y_{tA3} = 0.004 + 0.285 *AC\_21 - 0.268 * AD\_27 - 0.052 * AE\_10 + 0.447 * AE\_21 + MA(1)\ 0.499$ (5)

$\sigma^2_{tA3} = 5.31E\text{-}05 + 0.476 * \alpha + 0.638 * \beta - 0.572 * \gamma$ (6)

A4_ PSV 700m² deck 5yo - SHP $m

$y_{tA4} = -0.112 + 0.474 * AC\_19 + 0.468 * AD\_16 - 0.1228 * AF\_12 - 0.083 * AC\_14 + 0.012 * AC\_11 + 0.075 * AC\_15 + [AR(1)=0.839, MA(1)=-0.796]$ (7)

$\sigma^2_{tA4} = 1.71E\text{-}06 + -0.055 * \alpha +1.070 * \beta - 0.008 * \gamma$ (8)

ANCHOR HANDLING TOWING SUPPLY VESSELS TC RATE AND SECOND HAND PRICE

A5_AHTS 12,000 bhp TC Rates, WAFR

$y_{tA5} = -0.005 + 0.195 * AB\_14 + 0.290 * AB\_15 - 0.183 * AC\_16 - 0.075 * AE\_20 + [AR(1)=0.557, AR(2)=-0.897, MA(1)=-0.418, MA(2)=0.999]$ (9)

$\sigma^2_{tA5} = 0.0003 +0.494 * \alpha + 0.292 * \beta - 0.227 * \gamma$ (10)

A6_AHTS 12,000 bhp 5yo - SHP - $m

$y_{tA6} = 0.0009 + 0.080 * AB\_12 - 0.564 * AB\_13 + 0.399 * AC\_22 + 0.255 * AD\_16 + 0.095 * AE\_18$ (11)

$\sigma^2_{tA6} = 7.96E\text{-}05 + 0.149 * \alpha + 0.911 * \beta -0.285 * \gamma$ (12)

A7_ AHTS 80t BP TC Rate, Global Indicator - $/day

$y_{tA7} = 0.147 + 0.241 * AC\_16 - 0.145 * AD\_10 + 0.053 * AD\_18 + 0.261 * AE\_21 + 0.189 * AF\_12 + 0.016 * AC\_11 + [AR(1)=-0.230, MA(1)=0.8378]$ (13)

$\sigma^2_{tA7} =4.06E\text{-}05 + 1.174 * \alpha + 0.488 * \beta - 1.072 * \gamma$ (14)

A8_AHTS 7,000 bhp 5yo - SHP

$y_{tA8} = 0.066 + 0.207 * AC\_19 + 0.327 * AD\_15 - 0.007 * AC\_11$ (15)

$\sigma^2_{tA8} = 0.0001 + 10.275 * \alpha + 0.061 * \beta - 9.355 * \gamma$ (16)

AB_12	Brent Crude Oil Price - $/bbl	**AD_11**	North America- Total Drillships Utilisation %
AB_13	Global Oil Prod - Mbpd	**AD_15**	PSV 700m² deck Resale Price - $m
AB_14	MGO Bunker Price - $/Tonne	**AD_16**	***PSV 800m² deck 5yo - SHP - $m**
AB_15	PSV/Supply Orderbook - GT	**AD_17**	Fleet > Mobile Production - No
AC_11	PSV 500-899m² Spot Rate, North Sea - £/day	**AD_18**	Orderbook > Mobile Production > SS Prod - No
AC_14	AHTS 18,000 bhp TC Rates, Brazil $/day	**AD_27**	Fleet > FPSO Conversions - No
AC_15	PSV 750-899m² deck TC Rates, US Gulf - $/day	**AE_10**	Laid-Up Vessels, Global: Total OSVs - No
AC_16	South America-Active No of Floaters	**AE_18**	North Sea- 3,500-10,000 ft Utilisation - %
AC_17	***PSV 3,200 dwt TC Rate, Global Indicator - $/day**	**AE_20**	UK-Active No of Jack-Ups
AC_19	***AHTS 12,000 bhp 5yo - SHP - $m**	**AE_21**	***PSV 4,000 dwt TC Rate, Global Indicator - $/day**
AC_21	***AHTS 80t BP TC Rate, Global Indicator - $/day**	**AE_21**	***PSV 4,000 dwt TC Rate, Global Indicator - $/day**
AC_22	***PSV 700m² deck 5yo - SHP $m**	**AF_12**	AHTS 12,000 bhp TC Rates, S.E Asia - $/day
AD_10	South America-Active No of Drillships		

Note: * are dependent variables

Table 28 shows the summary of the characteristics for the developed models. Lagged squared residuals, asymmetry terms, lagged conditional variance terms and the R-squared factors are included in the table to compare the performance of the models and determine further strategies based on these results.

Table 28. GARCH Models Variance Equations Statistics

OLS_ Name	Description	R-Squared	α	ɣ	β
Regression					
*D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator	0.545	0.157 (0.924)	0.730 (0.000)	0.654 (0.000)
*D_LOG_A2_PSV_SHP	PSV 5yo 800m2 deck - SHP	0.622	0.754 (0.000)	-0.556 (0.001)	-0.171 (0.000)
*D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator	0.703	0.476 (0.004)	-0.572 (0.000)	0.639 (0.000)
*D_LOG_A4_PSV_2_SHP	PSV 5yo 700m2 deck - SHP	0.667	-0.055 (0.146)	0.008 (0.892)	1.071 (0.000)
*D_LOG_A5_AHTS_TC	AHTS 12,000 bhp TC Rates, WAFR	0.317	0.494 (0.132)	-0.228 (0.429)	0.292 (0.255)
*D_LOG_A6_AHTS_SHP	AHTS 12,000 bhp 5yo - SHP	0.622	0.149 (0.052)	-0.285 (0.001)	0.911 (0.000)
*D_LOG_A7_AHTS_2_TC	AHTS 80t BP TC Rate, Global Indicator	0.499	1.175 (0.022)	-1.073 (0.039)	0.488 (0.000)
*D_LOG_A8_AHTS_2_SHP	AHTS 7,000 bhp 5yo - SHP	0.282	10.275 (0.502)	-9.356 (0.531)	0.061 (0.327)

Note: (α) is lagged squared residual - ARCH term, (ɣ) is asymmetry term and (β) is lagged conditional variance – GARCH(-1) term. Parentheses (.) are p-values, and * is dependent variable.

When the GARCH term (*β*) goes up or down, the volatility of today will depends on yesterday´s volatility. The presence of volatility leverage in the model can be determined in the cases where the asymmetry term (*γ*) is positive and significant, meaning that negative news have a higher impact to the model than positive news of the same magnitude.

What stands out in Table 28 is the fact that the regression *PSV 4,000 dwt T/C Rate, Global Indicator* is the only model that presented both: volatility cluster phenomenon as showed column (*β*) and volatility leverage effect presented in column (*ɣ*). The volatility and errors are perceived by the model and negative news are having higher impact to the model as the positive events of similar magnitude. Not strong arguments were found to determine that the models *AHTS 12,000 bhp T/C Rates – WAFR* and *AHTS 7,000 bhp 5yo – SHP* present volatility effect. Tables 29 and 30 shows the final model for the regressions *AHTS 12,000 bhp T/C Rates, WAFR* and *AHTS 7,000 bhp 5yo - SHP*.

Table 29. Final model AHTS 12,000 bhp T/C Rates – WAFR

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A5_AHTS_TC		AHTS Term Charter Rates, WAFR, 12,000 bhp	
C	-0.006	Constant	0.076
D_LOG_AB_14	0.196	MGO Bunker Price	0.000
D_LOG_AB_15	0.291	PSV/Supply Orderbook	0.000
D_LOG_AC_16	-0.183	South America-Active No of Floaters	0.007
D_LOG_AE_20	-0.076	UK-Active No of Jack-Ups	0.000
AR(1)	0.558		0.000
AR(2)	-0.897		0.000
MA(1)	-0.419		0.000
MA(2)	1.000		0.000
Variance Equation			
C	0.000		0.061
RESID(-1)^2	0.494		0.132
RESID(-1)^2*(RESID(-1)<0)	-0.228		0.429
GARCH(-1)	0.292		0.256
R-squared	0.317	Mean dependent var	-0.006
Adjusted R-squared	0.272	S.D. dependent var	0.039
S.E. of regression	0.033	Akaike info criterion	-3.939
Sum squared resid	0.136	Schwarz criterion	-3.654
Log likelihood	271.005	Hannan-Quinn criter.	-3.823
Durbin-Watson stat	2.009		

Table 30. Final model AHTS 7,000 bhp 5yo - SHP

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A5_AHTS_TC		AHTS Term Charter Rates, WAFR, 12,000 bhp	
C	-0.006	Constant	0.076
D_LOG_AB_14	0.196	MGO Bunker Price	0.000
D_LOG_AB_15	0.291	PSV/Supply Orderbook	0.000
D_LOG_AC_16	-0.183	South America-Active No of Floaters	0.007
D_LOG_AE_20	-0.076	UK-Active No of Jack-Ups	0.000
AR(1)	0.558		0.000
AR(2)	-0.897		0.000
MA(1)	-0.419		0.000
MA(2)	1.000		0.000
Variance Equation			
C	0.000		0.061
RESID(-1)^2	0.494		0.132
RESID(-1)^2*(RESID(-1)<0)	-0.228		0.429
GARCH(-1)	0.292		0.256
R-squared	0.317	Mean dependent var	-0.006
Adjusted R-squared	0.272	S.D. dependent var	0.039
S.E. of regression	0.033	Akaike info criterion	-3.939
Sum squared resid	0.136	Schwarz criterion	-3.654
Log likelihood	271.005	Hannan-Quinn criter.	-3.823
Durbin-Watson stat	2.009		

There was a significant reduction of variables during the ARMA GARCH model-building process. Nineteen from forty-three variables of different nature, such as AHTS Spot Rates for AHTS 16-20,000 bhp in the North Sea (AF_10) or Total Global Active Number of FPSOs (AD_14) were excluded because it was found to be non-significant in any of the models. The complete regressions statistics for the final GARCH models are presented in Appendix 9.

3.2.11. Forecasting

As the main objective of this research is to generate strategies for the chartering or S&P of OSVs, accurate forecasting become an important tool due to the necessity to determine, with an acceptable level of confidence, future values of freight rates and second-hand price of OSVs. The final result of the developed OLS ARMA GARCH model will be used to create forecasts using dynamic (multi-step) and statics (one-step-ahead) methods.

It is worth remembering that this study used 134 monthly observations dated from January 2008 to February 2019; the data set was used for all the regressions except for the eighth model *AHTS 7,000 bhp 5yo - SHP* where 116 monthly observations dated from January 2008 to August 2017 were used to build this specific model. For the first set of seven regressions, 120 observations were used as the in-sample for the forecast estimation. The in-sample dated from January 2008 to January 2018, and the out-of-sample dated from February 2018 to February 2019. The forecast for the eighth model was estimated using an in-sample from January 2008 to December 2016, and the remaining eight observations were reserved for out-of-sample forecasting.

After the models were completed and found to be consistent, the static and dynamic forecast is estimated, where the forecasting capability and accuracy is analysed using Mean Squared Error (MSE), Mean Absolute Error (MAE) and the Mean Absolute Percentage Error (MAPE).

The following criteria is of help to the researcher to make a diagnosis of the forecasts' accuracy, in order to determine if it is correct and hence are accepted:

1. Not biased, meaning that the bias proportion should be close to 0
2. Small variance proportion, in other words, the variance should be less than the covariance proportion.

Table 31 presents the description of the forecasting performance for each of the models. Complete forecast estimations and graphs can be found in Appendix 10.

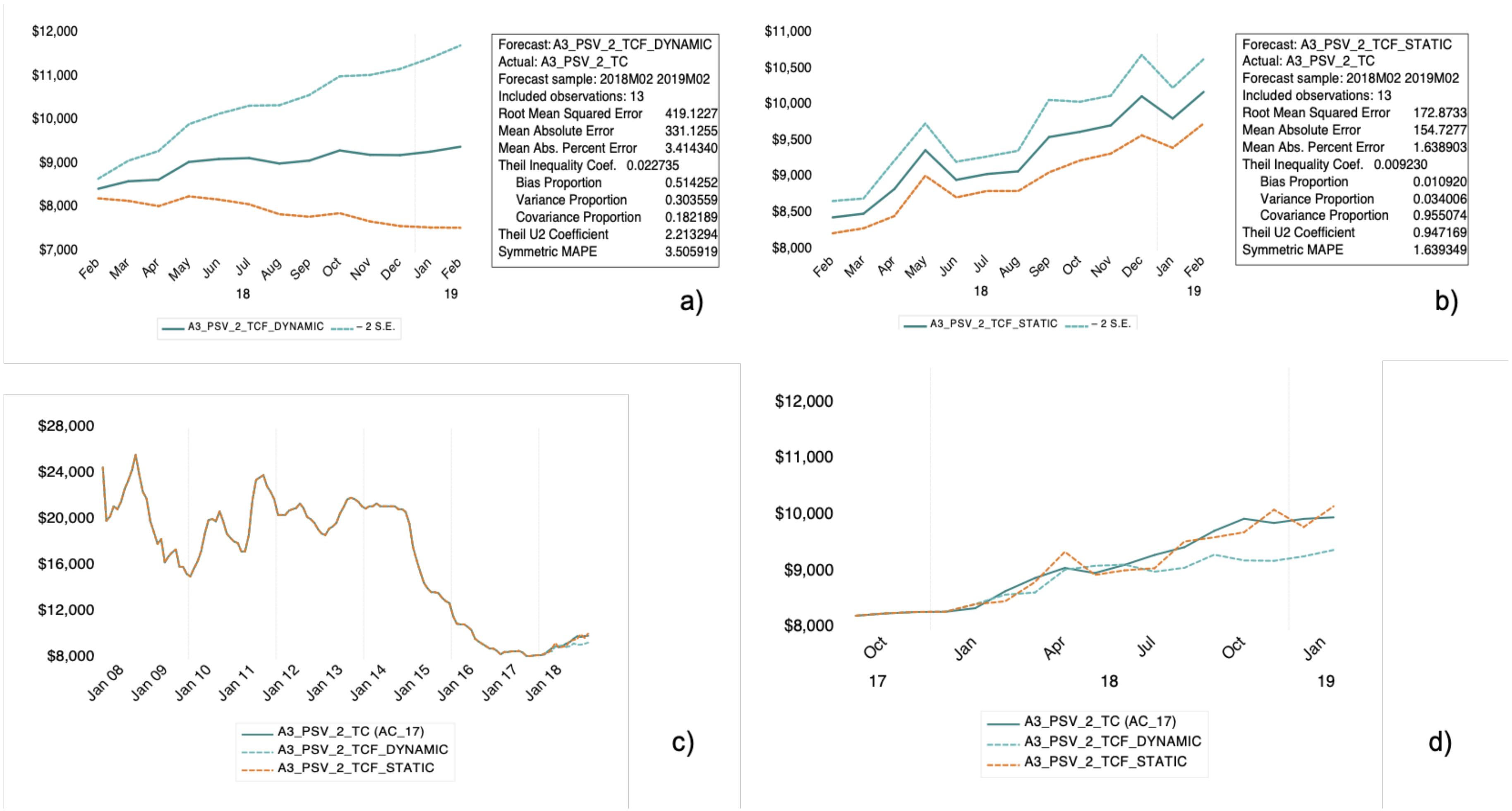
Table 31. Forecasts (Dynamic and Static) statistics summary

Forecast Name	MSE	MAE	MAPE	Bias Prop.	Variance Prop.	Covariance Prop.
A1_PSV 4,000 dwt T/C Rate_ Dynamic	407.517	335.982	2.756	0.168	0.274	1.212
A1_PSV 4,000 dwt T/C Rate_ Static	321.781	235.558	1.954	0.002	0.018	0.980
A2_PSV 800m² deck 5yo - SHP_Dynamic	2.187	2.137	21.806	0.955	0.011	0.033
A2_PSV 800m² deck 5yo - SHP_Static	0.478	0.326	3.221	0.183	0.108	0.709
A3_PSV 3,200 dwt T/C Rate_Dynamic	419.123	331.126	3.414	0.514	0.304	0.182
A3_PSV 3,200 dwt T/C Rate_ Static	172.873	154.728	1.639	0.011	0.034	0.955
A4_PSV 700m2 deck 5yo - SHP_Dynamic	0.743	0.691	15.013	0.864	0.008	0.128
A4_PSV 700m2 deck 5yo - SHP_Static	0.229	0.187	4.148	0.140	0.003	0.857
A5_AHTS 12,000 bhp T/C Rates_Dynamic	1088.377	919.814	6.958	0.703	0.045	7.721
A5_AHTS 12,000 bhp T/C Rates_Static	358.529	287.111	2.180	0.114	0.199	0.688
A6_HTS 12,000 bhp 5yo - SHP_Dynamic	0.254	0.191	2.576	0.333	0.136	0.531
A6_HTS 12,000 bhp 5yo - SHP_Static	0.233	0.180	2.460	0.046	0.010	0.944
A7_AHTS 7,000 bhp 5yo - SHP_Dynamic	337.048	306.478	7.017	0.827	0.011	0.162
A7_AHTS 7,000 bhp 5yo - SHP_Static	119.341	101.626	2.350	0.018	0.143	0.839
A8_AHTS 80t BP T/C Rate_Dynamic	0.227	0.184	2.523	0.630	0.000	0.370
A8_AHTS 80t BP T/C Rate_Static	0.178	0.139	1.937	0.060	0.002	0.938

Note: 1) MSE is mean square error, MAE is mean absolute error and MAPE is mean absolute percentage error. 2) the table present the evaluation results for the static and dynamic forecast estimations.

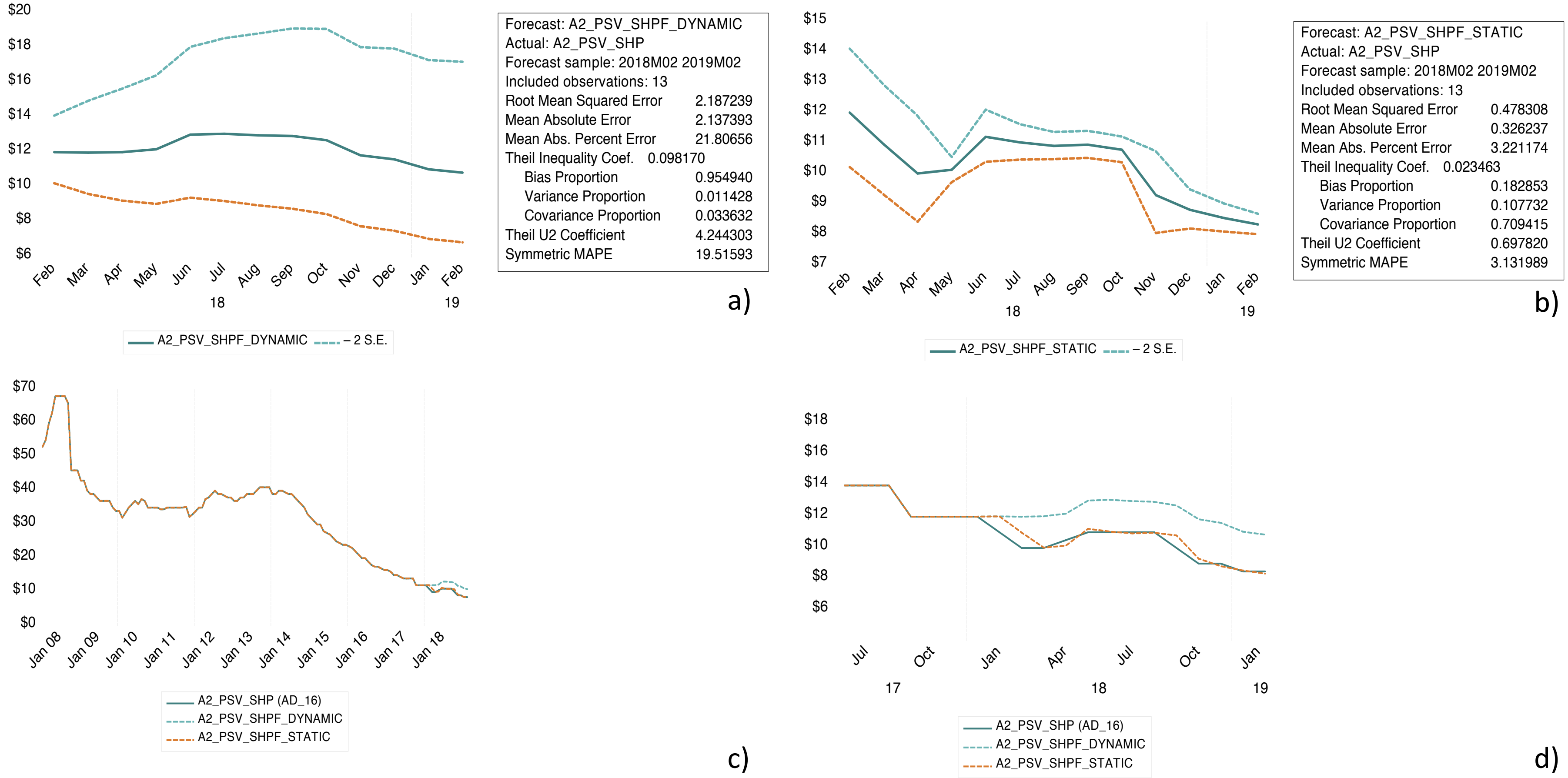
As can be seen from the forecast result in the Table 31, the static forecast performs better that the dynamic in all the cases. The MAPE for all the models is above one, meaning that the forecasts are reliable, being the forecast *A3_PSV 3,200 dwt T/C Rate_ Static* (Figure 23) the model with the lowest MAPE. The model *A2_PSV 800m² deck 5yo - SHP_Dynamic* (Figure 24) presented the highest MAPE.

Figure 23. **Forecast results for PSV 3,200 dwt T/C Rate Global Indicator**



a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Figure 24. **Forecast results for: PSV 800 m2 deck – SHP**



a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values

4 Findings

It is of interest for the researcher to establish the relationship between variables and explore how each of the T/C rates and SHP dependent variables is explained. The following chapter presents the outcomes identified from the regressions-built process for this research. The name of the dependent variables is in *italics* and coefficients in *(parenthesis)*.

4.1 Relationship between variables

The first result of this study, and contrary to some of those expected is that the Brent Crude Oil price and Global Oil Production are not explanatory variables for seven of the eight dependent variables examined in this research, and are only significant to *AHTS 12,000 bhp 5yo – SHP*. This finding is contrary to that of Ådland et al. (2017) who found that oil prices and oil production significantly affects OSV dayrates. Nevertheless, it is essential to bear in mind that their research only considered the OSV spot market in the North Sea, which is a volatile and seasonal segment of the OSV market, able to react rapidly to market changes due the length of the fixtures of less than 30 days, and may differ from the dynamics of the Global Indicators for T/C and SHP as is the case of this study. On the other hand, this finding may be supported by the hypothesis of Khalifa, Caporin, and Hammoudeh, (2017) which found that the relationship between changes in oil prices and the oilrig count[18] exists but is lagged, non-contemporaneous, and changes its intensity and stability over time, having its highest point in the bearish seasons of the oil market. Another possible explanation for this finding is related to the study performed by Ringlund et al. (2008) which concluded that there are variations in the strength of the relation between oil price and oilrig demand across regions (e.g. OPEC and non-OPEC countries), combined with other significant factors like seasonal weather conditions, hurricanes and oil companies' spending patterns[19], that are reflected by the nature of the company.

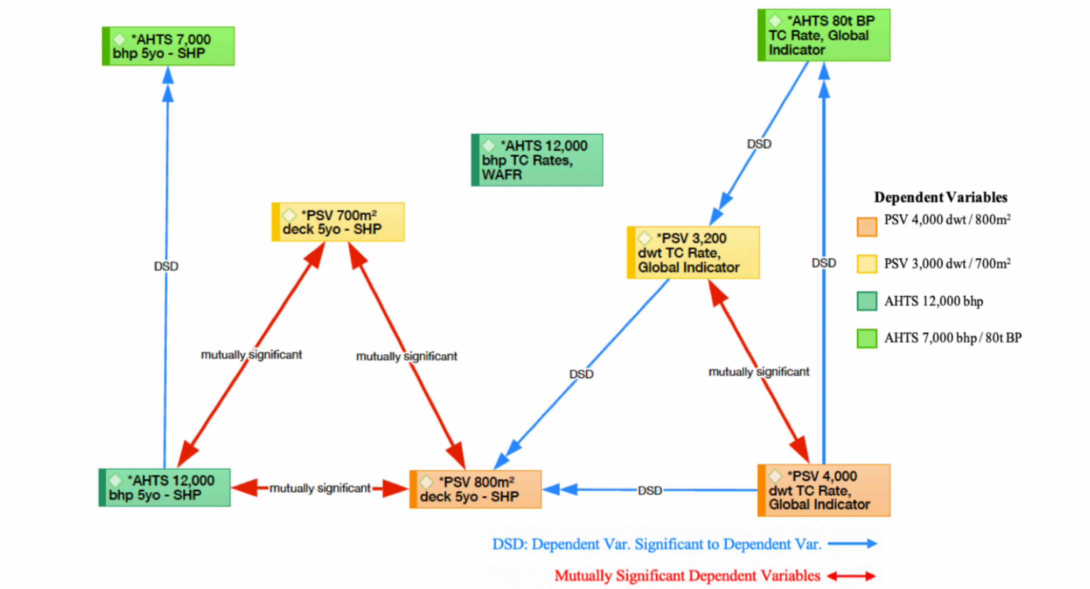
Another important finding of this research is the statistical evidence of interrelationship between different variables of the offshore O&G operation identified in the theoretical framework. The final ARMA GARCH models indicated the existence of relationship between dependent variables as illustrated in the Figure 25, particularly the Second-hand price variables: *AHTS 12,000 bhp 5yo, PSV 700m² deck 5yo* and *PSV 800m² deck 5yo* and the T/C Rates for *PSV 4,000 dwt* and *PSV 3,200 dwt* variable*s*, which are significant among them.

The Figure 26, shows all the relationships between all the selected variables where the *PSV 4,000 dwt T/C Rate - Global Indicator, PSV 500-899m² Spot Rate - North Sea* and *AHTS 12,000 bhp 5yo - SHP* are the regressors that influence the most dependent variables, each found to be significant in three different regressions, and hence may be considered as benchmark variables.

[18] Oilrigs are essential elements of the oil and gas operation. Rig count trends are governed by oil company exploration and development spending, which in turn is influenced by the current and expected price of oil and natural gas. Rig counts, therefore, reflect the strength and stability of energy prices (Baker Hughes a GE company, 2019) .

[19] State governments control national oil companies (NOCs) and the focus of their actions is the 'national interest'. International oil companies (IOCs) are publicly listed and controlled by private interests and respond in a very sensible manner to changes in the market dynamics (Clarksons Research Services, 2019).

Figure 25. Dependent Variables Relationship

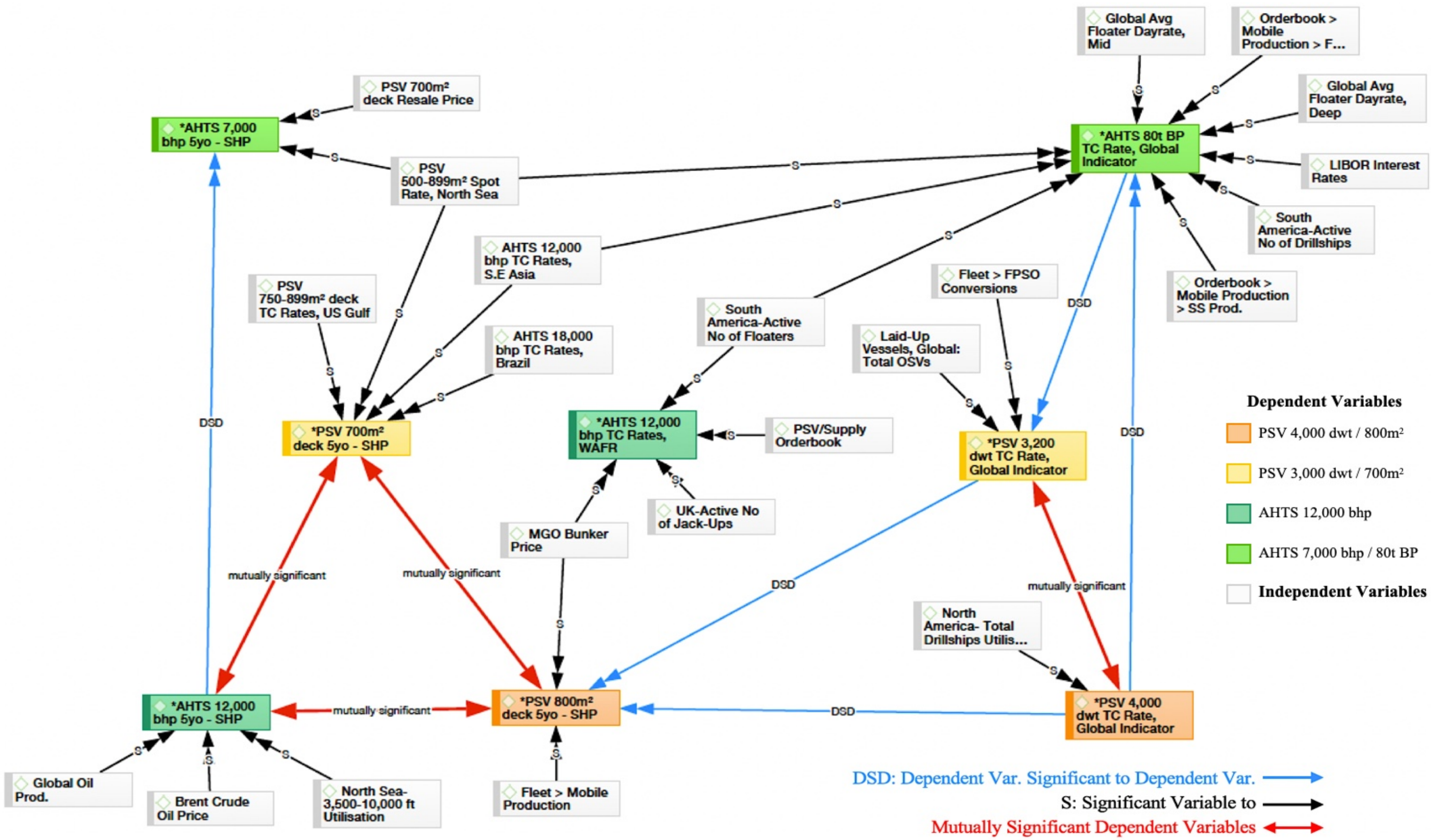


Notes: 1) The figure shows the significance and relationship of the dependent variables. 2) Each box represents a regression. 3) The blue arrows indicate a dependent variable which is explanatory in another regression. 4) The red arrows means that one dependent variable is also a significant independent variable in another regression (mutual significance).

The influential variables for the four PSV models examined in this study also presented essential results. Firstly, in addition to the mutual significance between *PSV 4,000 dwt and PSV 3,200 dwt T/C Rates*, these variables are explained by different regressors. *PSV 4,000 dwt* model was found to be significantly affected by only two variables: *North America- Total Drillships Utilization (-0.067)* and by the interrelation with *PSV 3,200 dwt T/C Rate Global Indicator (0.861)*. The negative coefficient of the *Drillships utilization in North America* variable is one unanticipated finding. This result is likely to be related to the oversupply of PSV above 3,000 dwt in North America (189 vessels circa July 2019) against the number of Drillships in the region and its utilization (79% of utilization for 25 available units circa July 2019) as reported by Clarksons Research Services (2019). In addition to the contracting strategies of the oil companies for long drilling projects, where for long-term contracts (typically one year), the contracts are mainly awarded through open bidding processes where T/C rates are determined principally by the supply and demand and the “competitive nature of bidding” (Kaiser, 2015, p65). The mutual interrelationship between both PSVs may partially be explained by the fact that *PSV 3,200 dwt* and *PSV 4,000 dwt* share similar areas of operation like West Africa or Deepwater Brazil and are employed for similar duties.

On the other hand, *PSV 3,200 dwt T/C Rates* is affected by four variables: *AHTS 80t BP T/C Rate - Global Indicator* (0.286), *Fleet > FPSO Conversions Number (-0.269), Total Laid-Up OSVs (-0.052), PSV 4,000 dwt T/C Rate - Global Indicator (0.448)*. It can therefore be assumed that the influence of the variable *PSV 3,200 T/C Rate (0.861)* on *PSV 4,000 dwt T/C Rate* is higher than in the opposite instance *(0.448),* which is relevant for the overall T/C Rate analysis. The more the number of laid-up vessels increase, the more negative information from the market that rates are low and vessels have no job. "Reactivation of lay-ups could prevent anything other than gradual improvement in rates (Clarksons Research Services, 2019, p12)". The influence of the *FPSO Conversions Number* and its negative coefficient is a surprising result, since it is expected that the more offshore production units are in operation, the more support from OSVs is required. Nevertheless, a possible explanation for this is the different nature between the exploratory or development drilling cycle and the production cycle, the latter meaning the transition from an intense operational activity (i.e. drilling) to a 'parsimonious' long production cycle -some cases up to 30 years (Skoko et al., 2013). Production is characterized by the sharp calculation and optimization of the OSV fleet, additionally to the circuital operational set-up of the fleet, where one single vessel attends more than one unit. The previous finding is also explained by Kaiser (2015) who found that in the US GoM the drilling activity requires 6.7 OSV trips per week while production only 3.7. It is necessary to highlight this result, particularly from an economic standpoint where the influence is relevant.

Figure 26. Variables Relationship



Notes: 1) The figure shows the significance and relationship of the variables. 2) Each of the colored boxes represents a regression. 3) The blue arrows indicate a dependent variable which is explanatory in another regression. 4) The red arrows means that one dependent variable is also a significant independent variable in another regression (mutual significance). 5) The black arrow is a significant independent variable to a dependent variable.

From the six significant regressors for the dependent variable *PSV 800m² deck 5yo – SHP*, three were found to have the most influence: *Fleet > Mobile Production – No (-0.895), AHTS 12,000 bhp 5yo - SHP - $m (0.422),* and the intercorrelation with *PSV 700m² deck 5yo – SHP- $m (0.427).* The positive influence of the latter two was an expected outcome due to the similar operational market and the direct influence among these vessels. The justification regarding the negative coefficient of *Mobile Production Number of Units* is similar to that found between *PSV 3,200 dwt T/C Rates* and *Mobile FPSOs* where the production stage requires fewer OSVs. With reference to the other regressors, first, the negative coefficient of *PSV 3,200 dwt T/C Rate - Global Indicator - $/day (-0.291)* may be explained by the fact that increments in the T/C Rate of its direct competitor (*PSV 3,200 dwt*) may bring negative information into the model such as a reduction in the usage or requirement of *PSV 800m²deck,* and hence a reduction in the SHP. Second, *MGO Bunker Price - $/Tonne (0.065)* can be explained in part by the high consumption of MGO of this type of vessel, the economic impact of MGO to the offshore projects' economy, and hence the transfer of information to the SHP. Third, the positive influence of *PSV 4,000 dwt T/C Rate - Global Indicator - $/day (0.285)* is due that freight rates of the same type of PSV, are considered as the main influence in the cost of the vessel and are the mechanism that influences investment decisions (Stopford, 2009).

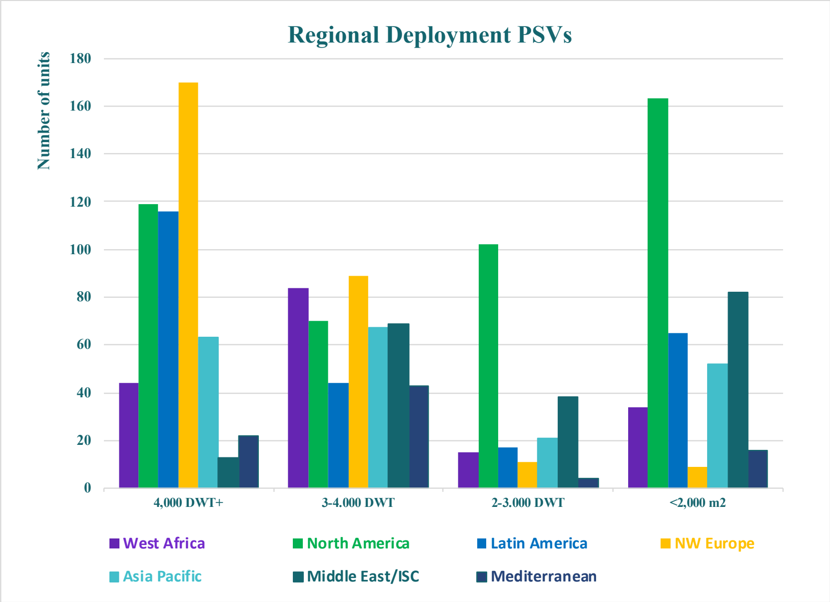
For the model for *PSV 700m² deck 5yo – SHP,* the following are the variables found to be significant in the regression:

- *AHTS 12,000 bhp T/C Rates, S.E Asia - $/day (-0.123)*
- *AHTS 18,000 bhp T/C Rates, Brazil - $/day (-0.083)*
- *PSV 500-899m² Spot Rate, North Sea - £/day (0.012)*
- *PSV 750-899m² deck T/C Rates, US GoM - $/day (0.076)*
- *AHTS 12,000 bhp 5yo - SHP - $m (0.475)*
- *PSV 800m² deck 5yo – SHP - $m (0.468)*

As can be observed, all the significant variables are OSV related, either T/C rates or SHP, representing main offshore regions. There are no other influences on the dependent variable such as MODUs rates or the fleet number of MOPU. The previous information is valuable when defining S&P opportunities since the understanding of the regional information that influence this variable is indispensable. The negative influence of *AHTS T/C rates in Brazil* and *South East Asia* seems to be explained because in some critical regions (e.g. Southeast Asia) the duties for PSV and AHTS overlap, utilising the AHTSs to supply offshore units instead of PSVs (Clarksons Research Services, 2019a), thus meaning that the increment in the usage of these types of AHTSs is signifying a reduction of the employment of *PSV 700 m2 deck* and hence affecting the SHP. On the other hand, the reciprocal significance between the *PSV 700m² deck 5yo – SHP* and *PSV 800m² deck 5yo – SHP* is of similar magnitude (*0.468* against *0.427*), indicating that there is no predominance of any of the aforementioned dependent variables, and the mutual significance is balanced.

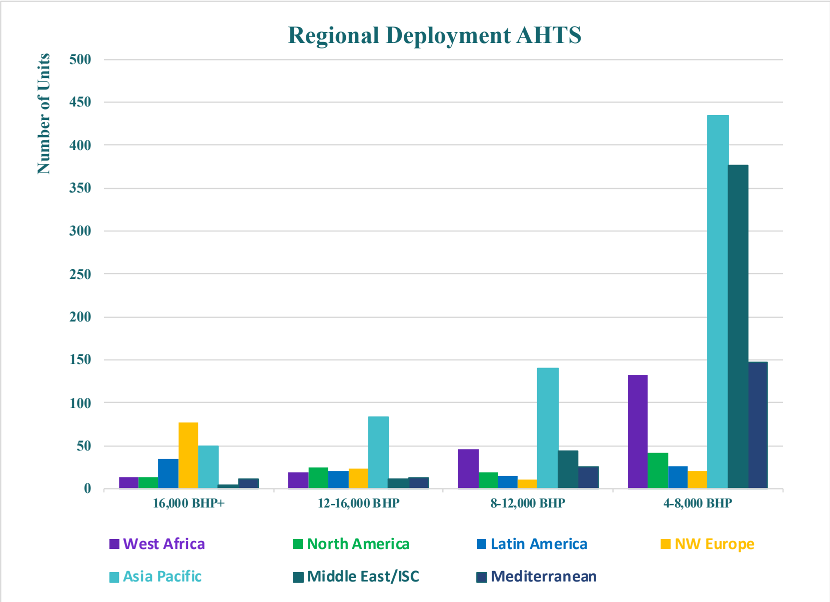
The second set of examined regressions are *AHTS T/C rates* and *SHP.* The variable *AHTS 12,000 bhp WAFR* was found to be unaffected by any of the other dependent variables analysed in this study. According to the results, this variable is influenced by *MGO Bunker Price* (0.196), *PSV/Supply Orderbook – GT (0.291), South America-Active Number of Floaters (-0.183),* and *UK-Active Number of Jack-Ups* (-0.076). These results may be explained in part by the high consumption of MGO of this type of vessel, and similar to *PSV 800 m^2 deck*, this item (MGO) is of importance to the expenditure in offshore projects. What is surprising is the negative coefficient of the variables *Active Number of floaters in South America (-0.183)* and *UK-Active Number of Jack-Ups (-0.076):* a result that suggests that this kind of operation employs more the PSV fleet (Figure 27 and 28) and therefore influence the T/C rates of AHTS.

Figure 27. **Regional Deployment of PSV by type among offshore regions**



Note: Data retrieved from Clarksons OIN database circa July 2019

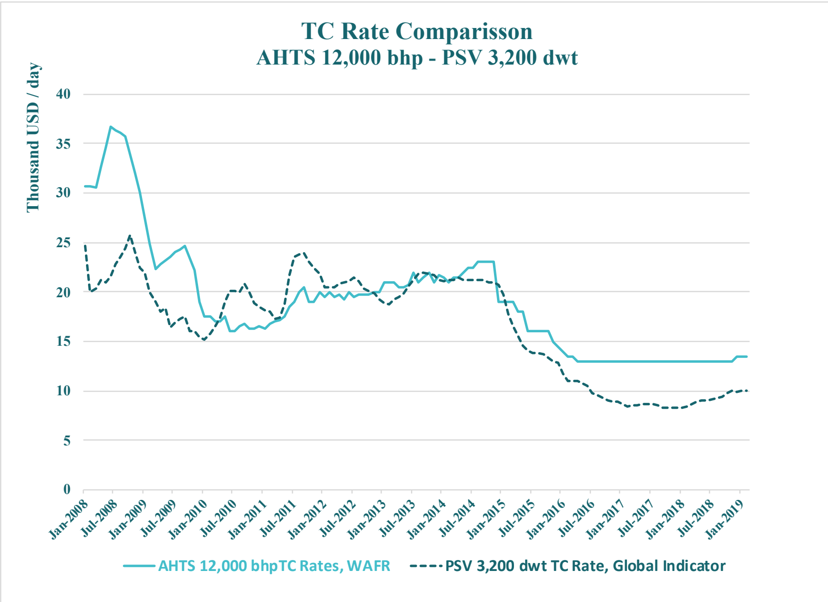
Figure 28. **Regional Deployment of AHTS by type among offshore regions**



Note: Data retrieved from Clarksons OIN database circa July 2019

When comparing the T/C Rate between AHTS 12,000 bhp and PSV 3,200 dwt from an offshore supply role perspective, the usage of the PSV is more likely since PSV T/C rates are more favourable, as presented in Figure 29.

Figure 29. **T/C rates comparison between PSV 3,200 dwt and AHTS 12,000 bhp**



Note: Data retrieved from Clarksons OIN database circa July 2019

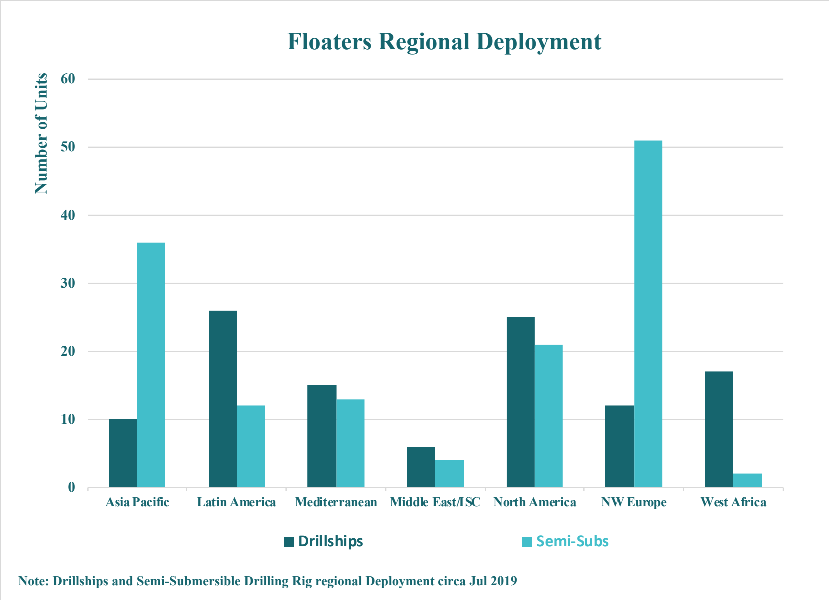
In the case of the regression *AHTS 12,000 bhp 5yo – SHP*, the results surprisingly showed that this variable is influenced by *PSVs 700 m2- SHP (0.400)* and *PSV 800m2 – SHP (0.255),* this reflects the strong competence between AHTS and PSVs, mainly due to the overlapped duties is some regions. It is somewhat unusual that the SHP of the *AHTS 12,000 bhp* is not influenced by any of the other AHTS related variables like *AHTS 12,000 bhp WAFR*, *AHTS 80t BP T/C Rate* or *AHTS 7,000 bhp SHP*, and is the only variable found to be influenced by the *Global Oil Prod (-0.565)* and *Brent Crude Oil Price - $/bbl (0.081).* This relationship is difficult to explain after seeing the results of the other seven dependent variables where the Oil Price resulted to be insignificant. The negative influence of *Global Oil Production* is basically following the effect from having abundance in a natural resource such as oil, which is negatively correlated with an increase in price (Black & LaFrance, 1998), and hence this event is giving negative information to this specific variable. On the other hand, increases in oil prices seems to stimulate *AHTS 12,000 SHP* - this worth further investigation.

AHTS 80t BP T/C Rate - Global Indicator comprises the largest segment of the OSV fleet, with 1,177 vessels globally as reported by Clarksons Research (2019). The regressors found to have positive significance to the dependent variable are:

- *South America-Active No of Floaters (0.242)*
- *Orderbook > Mobile Production > SS Prod. Facility (0.054)*
- *PSV 4,000 dwt T/C Rate, Global Indicator (0.261)*
- *AHTS T/C Rates, South East Asia, 12,000 bhp (0.189)*
- *PSV Spot Rate, North Sea, 500-899m² (0.016)*

There are several possible explanations for this result. The first explanation may be due the large number of vessels deployed mainly in the Middle East and Asia Pacific, where the T/C rates in this region directly influence this variable. Second, is the overlapped role of this type of vessels and PSVs and the influence of benchmark variables as *PSV Spot Rate in the North Sea* and *PSV 4,000 T/C Rate Global*. A possible explanation for the negative coefficient of *South America-Active No of Drillships (-0.146)* may be the fact that it is not usual to utilize small AHTS to supply drill ships in deep-water environments like Brazil or the GoM. Consequently, the increment in the utilization of these types of drilling units in these areas suggests more employment of larger OSVs and a possible disregard of small AHTS. The contrary is the case for mid and shallow water operations (Figure 30), where the usage of smaller OSVs is more common as is the case of the operations in some areas in Asian waters or the Middle East where most of these vessels are deployed, this explain the positive significance.

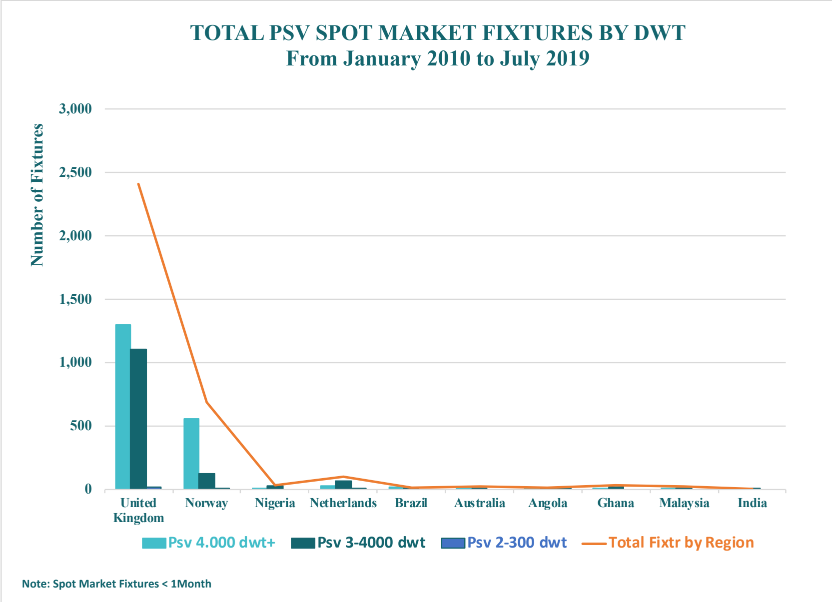
Figure 30. **Regional Deployment of Drillships and Semi-Subs**



Note: Data retrieved from Clarksons OIN database circa July 2019

The last model to be explained is the *AHTS 7,000 bhp 5yo – SHP*. This regression has three significant variables: *AHTS 12,000 bhp 5yo - SHP - $m (0.207), PSV 700m² deck Resale Price - $m (0.327)* and *PSV 500-899m² Spot Rate - North Sea - £/day (-0.007)*. The positive coefficient indicates a strong relationship between variables, and in some way, signs of market sharing. The significance of the *Resale price of PSV 700m² deck* is of interest since this specific variable collects information from any demand improvement that induces to speculative asset-plays (Clarksons Research Services, 2019), hence this market information is transferred to the AHTS SHP (due to the overlap of duties in different regions). The negative coefficient of *PSV 500-899m² Spot Rate - North Sea* explains the strong influence of this variable as a benchmark of the market with 3,090 fixtures between 2010 and 2019, as reported by Clarksons Research Services (2019) and presented in see Figure 31.

Figure 31. **Worldwide PSV fixtures from January 2010 to July 2019**



Note: Data retrieved from Clarksons OIN database circa July 2019

This chapter presented the model-building process outcomes and the relationship between variables, identifying how the regressors used in the models explain the different dependent variables. Table 32 presents the summary of the eight different models built for this study and the significance of the regressors.

Table 32. Variables Relationship Matrix

	Significant Explanatory Variables ARMA GARCH Model	*PSV 4,000 dwt TC Rate, Global Indicator		*PSV 800m² deck 5yo - SHP		*PSV 3,200 dwt TC Rate, Global Indicator		*PSV 700m2 deck 5yo - SHP		*AHTS 12,000 bhp TC Rates, WAFR		*AHTS 12,000 bhp 5yo - SHP		*AHTS 80t BP TC Rate, Global Indicator		*AHTS 7,000 bhp 5yo - SHP		
		Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Coefficent	P-value	Total
	R-squared	0.545		0.622		0.703		0.667		0.317		0.622		0.499		0.282		
	C	0.000	0.892	0.004	0.160	0.005	0.052	-0.113	0.001	-0.006	0.076	-0.001	0.603	0.148	0.000	0.067	0.062	
AE_21	***PSV 4,000 dwt TC Rate, Global Indicator - $/day**			↑ 0.285	0.000	↑ 0.448	0.000							↑ 0.261	0.000			3
AC_11	PSV 500-899m² Spot Rate, North Sea - £/day							↑ 0.012	0.001					↑ 0.016	0.000	↓ -0.007	0.001	3
AC_19	***AHTS 12,000 bhp 5yo - SHP - $m**			↑ 0.422	0.000			↑ 0.475	0.000							↑ 0.207	0.025	3
AC_16	South America-Active No of Floaters									↓ -0.183	0.007			↑ 0.242	0.000			2
AF_12	AHTS 12,000 bhp TC Rates, S.E Asia - $/day							↓ -0.123	0.055					↑ 0.189	0.000			2
AD_16	***PSV 800m² deck 5yo - SHP - $m**							↑ 0.468	0.000			↑ 0.255	0.000					2
AC_22	***PSV 700m² deck 5yo - SHP $m**			↑ 0.427	0.000							↑ 0.400	0.000					2
AC_17	***PSV 3,200 dwt TC Rate, Global Indicator - $/day**	↑ 0.861	0.000	↓ -0.291	0.004													2
AB_14	MGO Bunker Price - $/Tonne			↑ 0.065	0.041					↑ 0.196	0.000							2
AD_18	Orderbook > Mobile Production > SS Prod - No													↑ 0.054	0.000			1
AD_10	South America-Active No of Drillships													↓ -0.146	0.000			1
AD_15	PSV 700m² deck Resale Price - $m															↑ 0.327	0.049	1
AB_13	Global Oil Prod - Mbpd											↓ -0.567	0.010					1
AB_12	Brent Crude Oil Price - $/bbl											↑ 0.081	0.000					1
AE_18	North Sea- 3,500-10,000 ft Utilisation - %											↑ 0.096	0.000					1
AC_14	AHTS 18,000 bhp TC Rates, Brazil $/day							↓ -0.083	0.034									1
AC_15	PSV 750-899m² deck TC Rates, US Gulf - $/day							↑ 0.076	0.037									1
AD_17	Fleet > Mobile Production - No			↓ -0.895	0.037													1
AC_21	***AHTS 80t BP TC Rate, Global Indicator - $/day**					↑ 0.286	0.000											1
AE_10	Laid-Up Vessels, Global: Total OSVs - No					↓ -0.052	0.000											1
AD_27	Fleet > FPSO Conversions - No					↓ -0.269	0.016											1
AB_15	PSV/Supply Orderbook - GT									↑ 0.291	0.000							1
AD_11	North America- Total Drillships Utilisation %	↓ -0.067	0.051															1
AE_20	UK-Active No of Jack-Ups									↓ -0.076	0.000							1
	Total	2		6		4		6		4		5		6		3		

Note: * is a dependent variable.

5 Discussion

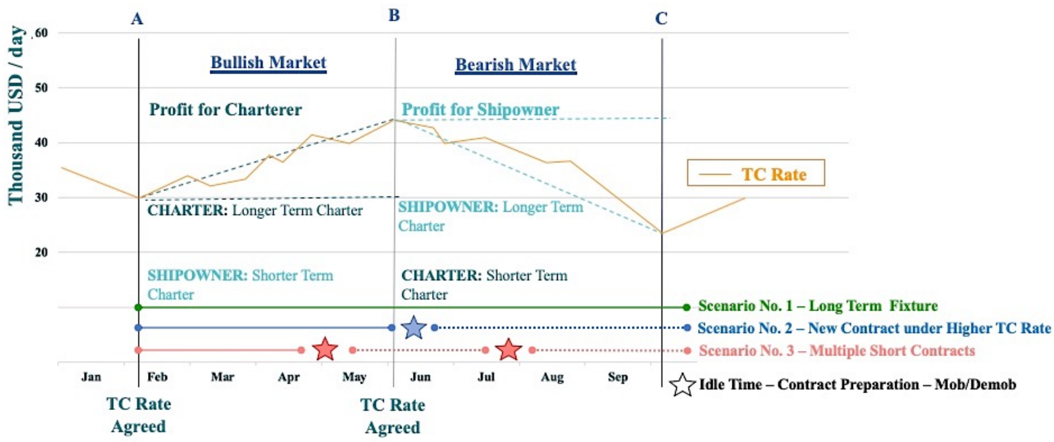
The findings presented in Chapter 4 are relevant for the examination of term charter rates and second-hand price dynamics, and the identification of timing and suitable strategies for S&P and chartering of OSVs in the context of the global offshore market. This chapter presents the tests performed to the T/C Rate and second-hand price under different scenarios. Name of the variables are in *italics*.

5.1 T/C Rates strategy

Once the explanatory variables are identified, and its relationship and dynamics are understood, it is necessary to define whether to seek long-term or short-term charters, supported by the information available and the forecasts interpretation. The forecast is a tool to be used not to predict precise events, but to reduce the uncertainty in understanding future events by the analysis of present information (Stopford, 2009).

From a shipowner perspective two options seems to be advantageous depending the relative profitability (Kavussanos, 1996). Firstly, an advantageous timing to establish long-term contracts should be when the analysis of the market indicates that it will probably enter into a bearish season, and therefore it would be of benefit to investigate the global activity and seek options for securing long-term contracts (Kavussanos & Alizadeh, 2002) as presented in Figure 32. Secondly, and contrary to the first situation, when the information indicates that the market is passing through a bullish season, a valid alternative should thus be to ensure shorter contracts, seeking the benefit of the increment in the rates for the upcoming contracts. At the same time, it is necessary to bear in mind, that according to the specific situation the charterer decision-making process may be affected by different influential factors, since a future fixture duration for an OSV is determined by the scope and length of the offshore operation to be developed, regional weather conditions, the water depth of the project, the offshore area leasing commitments, the nature of the oil company, and the E&P cycle (i.e. exploration, development, production or abandonment). The duration of exploratory drilling ranges from some weeks to a few months for each well, and more than one well may be drilled (Kaiser, 2010). However, this analysis is vital for the planning and execution of any offshore project expenditure.

Figure 32. **Fixtures Interpretation Scheme (3 test scenarios)**



Note: 1) The orange line represents the forecasted TC Rate for one year period and the green, blue and red lines are the three scenarios to test which strategy get better returns. 2) The star represents idle time of one month, where the vessels are not getting any payment either because the vessel is fixing a new contract, preparing for the next contract or under mobilization or demobilization. 3) A, B and C are the fixturing dates of the contracts associated with TC Rate (Thousand USD/day).

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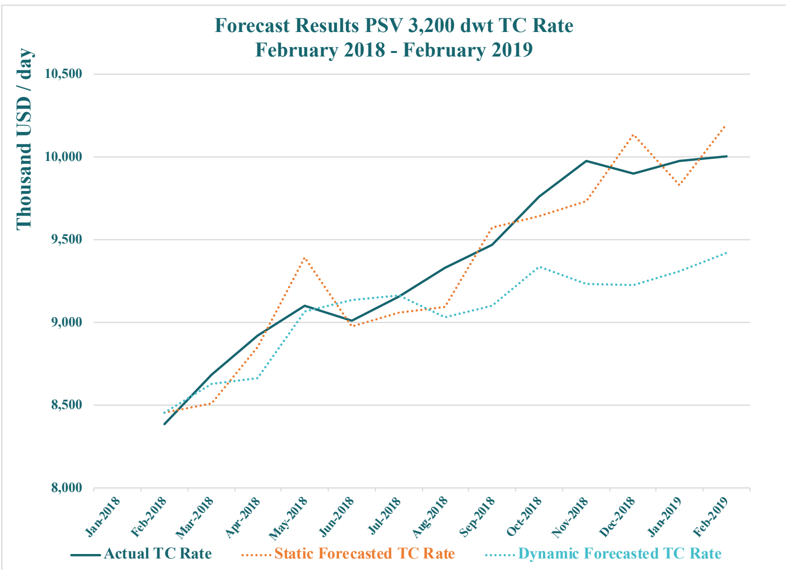
The three scenarios presented in Figure 32 were created to test three different strategies based on each of the forecasts of the T/C rates. The first scenario is a long-term contract for a one-year period and corresponds to the maximum forecasted months or 10% of the data sample (out-of-sample). The second scenario was considered under a six months initial contract, followed by one idle month (new fixture preparation – mobilization – no returns) and five months of a new contract at a new forecasted rate. This scenario may vary in one or two months according to the forecast information since it seeks to increase revenue by securing a new contract at a higher rate as suggested by Kavussanos and Alizadeh (2001). Finally, the third scenario of short contract fixtures (three to four months) with an idle month in-between each. This scenario is intended to determine the benefit of short fixtures under the expected volatility of the market. It is worth highlighting that these scenarios are simple tests of the forecasted rates to define a baseline strategy. From the oil company perspective, the actual driver is not to hire OSVs but the term of the offshore O&G projects, this may be interpreted that is as impractical for the oil operators (NOCs or IOCs) to change contracts in the middle of an operational window just because it is seeking benefits of lower rates, and hence, the benefits are more likely to be related to cost optimizations during planning phases of offshore oil activities campaigns.

5.1.1. Application in T/C Rate

Figure 33 shows the forecasted and the actual values for *T/C Rate for PSV 3,200 dwt*. The forecasted values are used to determine the strategy based on the different scenario (Figure 32) which may give lower risks and higher returns.

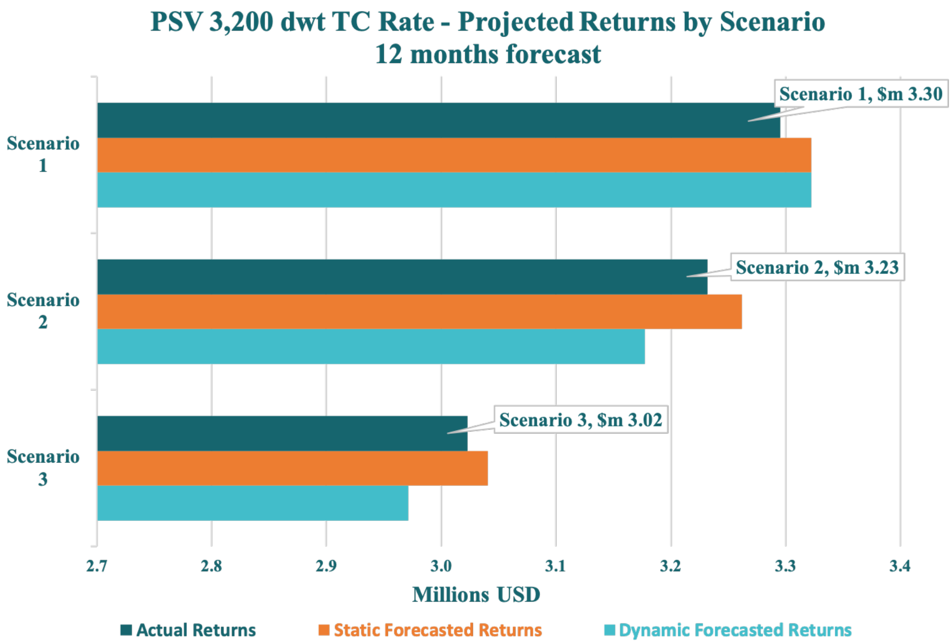
Figure 33. **Forecast Results for PSV 3,200 dwt T/C rate**

(Feb 2018 to Feb 2019)



According to the results presented in Figure 34, Scenario No. 1 (Long-Term charter for a whole year) presented the best performance. For the returns under the actual T/C rates, Scenario No. 1 is $ 63,550 above Scenario No. 2, and $ 272,040 above Scenario No.3. For Scenario No. 1 the actual returns compared to the estimated returns based on the dynamic and static forecasts showed to be $ 27,166 below. A note of caution is due here since the estimated income based on the forecast is higher than the actual income and hence a wrong expectation may arise. All the result of the scenario testing for all regressions are included in Appendix 11.

Figure 34. **Scenario Comparison for Returns under different strategies**



Note: the graph represents the test of the different scenarios for a period of one year from February 2018 to February 2019, period, which corresponds to the forecasted window. Each of the bands represents the total returns based on daily TC Rates obtained from the actual market as reported by Clarksons Research (2019) and the forecast (Statics and Dynamic).

In the case of *T/C Rate for PSV 3,200 dwt*, the projected scenarios suggest following a strategy of seeking long-term contracts of one-year duration; this is partially due the assumed idle time where the vessel preparing for a new contract or under mobilization for or from a region of operation that generate a reduction of the overall income. It is worth mentioning that the risk and timing associated with seeking new contracts is a fundamental factor to be considered (and further studied) if Scenario No. 2 or 3 are contemplated as strategies. The required T/C Rate for Scenario No. 2 to be viable over the same period with a return of \$ 300,000 (around 10% of the actual total return Figure 34) above Scenario No. 1 is around \$ 11,479 per day for the second fixture starting in September, this being an increment of about 24% of the initial rate of \$ 8,385 per day (see figure 33), which is not likely based on the forecast estimation, and also on the historical fluctuation of the T/C Rate for this type of vessel where the maximum monthly increment was 16% circa June 2011 (see Figure 35). It is also worth highlighting, that most of the operational costs are not considered in this study since the majority of them such as fuel, water, port charges, pilotage, light dues, among others, are typically covered by the charterer (BIMCO, 2017).

Table 33 presents the influence of the independent variables in the model. On average the *PSV 3,200 dwt T/C Rate* increases by 4.5% for each increment of 10% in *PSV 4,000 dwt T/C Rate*, and increases 3% for each 10% of increment in the *AHTS 80t BP T/C Rate*. The rate also decreases by 0.5% for each 10% increment in the OSV total laid-up vessels and decreases by 2.7% for the increment in the conversions of FPSO fleet by 10%. The detailed information of the expected variance at 10% increment for all the dependent variables are included in Appendix 12.

Table 33. Trend analysis for dependent variable *PVS 3,200 dwt T/C Rate*

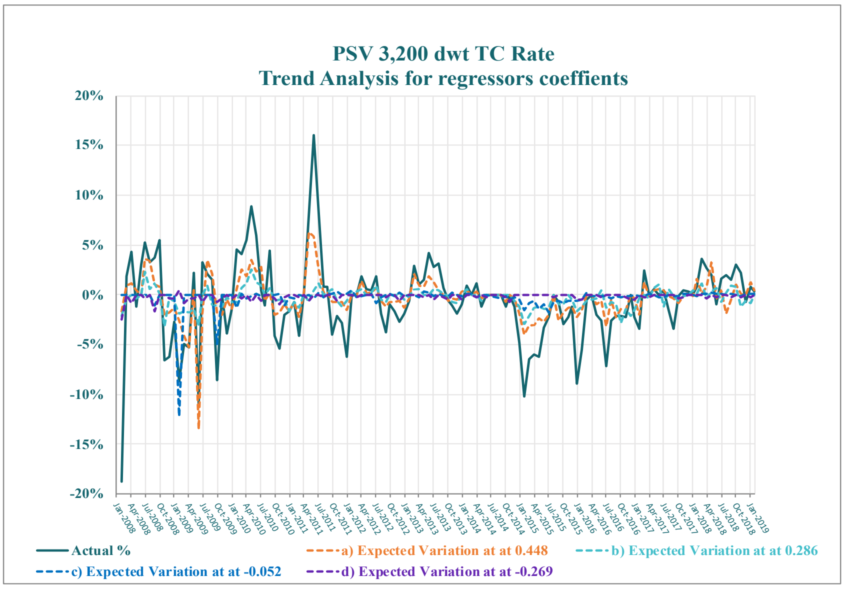
Coefficient	↑ 0.448	↑ 0.286	↓ -0.052	↓ -0.269
	Independent Variables			
	a) PSV 4,000 dwt TC Rate %	**b) AHTS 80t BP TC Rate %**	**c) Laid-Up Vessels: OSV Total %**	**d) Fleet > FPSO Conversions %**
1) Assumed Independent Variable Increment	10	10	10	10
***2) PSV 3,200 dwt TC Rate* - Dependent Variable change**	4.5 %	2.9 %	-0.5 %	-2.7 %

Note: 1) Independent variable increments of 10% on each independent variables are estimated values to test the influence of each of the regressors to the dependent variable.

2) Expected change on average of the value of the dependent variable by a 10% of increment on each of the independent variables, where regressors a) and b) presented the highest influence.

Figure 35 presents the percentage of how the *T/C Rate for PSV 3,200 dwt* reacted according to the coefficients estimated in the model. At some periods, the variable reacted as expected or overreacted, as is the case of June 2011, where the predicted increment of 5.9% at 0.448 was significantly lower compared to the actual of 16%. This result is essential when monitoring the market, since increases or drops in the rates may be anticipated. Additionally, it is essential to track the forecasting tool and detect if the predictions are performing according to the reality or the model needs adjustments or reconsiderations.

Figure 35. **Trend analysis for PVS 3,200 dwt T/C Rate and regressors**



Note: Actual variation is the variation in % of the T/C rate as reported by Clarksons Research (2019). The letters correspond to the influence of the regressors to the dependent variables based on the model coefficient and the actual variation of the independent variables: a) PSV 4,000 dwt TC Rate - Global Indicator, b) AHTS 80t BP TC Rate - Global Indicator, c) Laid-Up Vessels – Global Total OSVs and d) Fleet > FPSO Conversions.

The final point to consider when determining strategies or analysing the market is the volatility of the specific type of vessel. According to the results of the variance equation presented in Table 34, volatility cluster phenomenon is observed for *PSV T/C 3,200 dwt T/C Rate*, this means that significant changes in the market will be followed by same or even higher future fluctuation periods making them even more volatile than the previous. Nevertheless, low volatility periods are expected to be followed by future low or even lower volatility periods (Mandelbrot, 1963). No volatility leverage effect is present meaning that and adverse (negative) shocks have the same impact as positive shocks of the same magnitude.

Table 34. Volatility description for dependent variable *PVS 3,200 dwt T/C Rate*

OLS_ Name	Description	R-Squared	α	ɣ	β
Regression					
*D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator	0.703	0.476	-0.572	0.639
			(0.004)	(0.000)	(0.000)

Note: (α) is lagged squared residual - ARCH term, (ɣ) is asymmetry term and (β) is lagged conditional variance – GARCH(-1) term. Parentheses (.) are p-values, and * is dependent variable.

The information of the variance equation is essential information to define strategies, since risk-adverse charterers or shipowners would prefer to charter these types of vessels for extended periods. On the other hand, risk seekers would instead prefer to spot charter or fix the vessels for a shorter term in order to seek advantage from volatility and risk premium T/C rates.

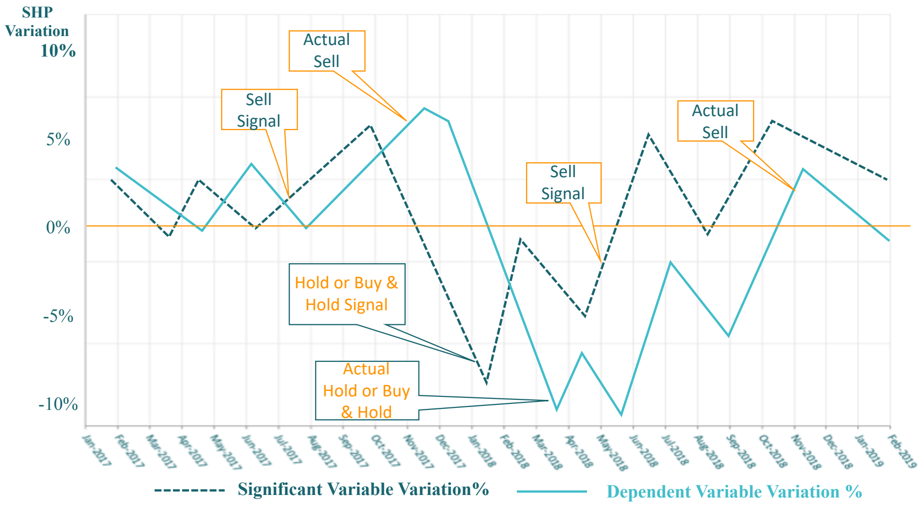
5.2 Second-hand price strategy

The results of this study are used to support a straightforward but suitable base strategy for sales and purchase of OSVs by interpreting the behaviour of the second-hand price before capital investment decisions. The fundamentals in the strategy for S&P are not very different from the ones for the chartering segment: same econometric tools are used, decisions are based on actual market circumstances, future markets performance are calculated, the regressors coefficients and the fast information of them are analysed, and the volatility of the assets are assessed and considered.

Figure 36 presents the main S&P strategy where the *buy and hold*, or *sell* signals are highlighted. Based on the information of the independent variables, which may be assumed to be a faster information, it can determine an estimated future change in the dependent variable of SHP by observing signals to *buy and hold* or *sell* the asset from the models (Ådland & Koekebakker, 2004).

The dotted line represents the estimated variation of the SHP based on the ARMA GARCH model regressors, it is assumed that if the estimated value of the independent variable increases in some percentage the dependent variable should increase in a similar (or superior) percentage of the regressor coefficient, this because the dependent variable reacts to the market information slower than the independent variables, and hence the faster information contains valuable evidence to make a decision for a slower market.

***Figure 36.* Sales & Purchase interpretation scheme**



Note: 1) Sell signal is when the expected variation provide early information that the future SHP may increase, and hence it may reach an Actual Selling point. 2) Hold or Buy & hold signal is when the expected variation give early information that the SHP may start to increase and hence a benefit of holding the vessel for a period where the new asset value represent a profit for the trader.

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In the case where the price trend does not react accordingly, it can be assumed that the vessel is under-priced, its value should increase in the future and hence a *hold* or *buy and hold* scenario is evidenced. In the opposite case, if the independent variable decreases and the vessel value does not decrease by the magnitude (or higher) estimated by the coefficient, the vessel SHP would decrease in the future (Ådland & Koekebakker, 2004) , meaning that holding the vessel may represent a financial loss, due to the overpriced market. When the overpriced situation is detected, a favourable strategy would be to *sell* the vessels, however, other alternative could be holding the vessel, seek an operational income in the form of T/C Rate and explore the alternative of selling or buying later, and therefore seek profit from volatility premium.

5.2.1. Application in Second-hand Price

For the specific case of *PSV 700 m2 deck – 5yo – SHP* the information to be analysed are the coefficients resulted from the regression (Table 35) to determine the strength of the influential variables based on an assumed increment percentage (10%) and the information that the regressors may provide for the SHP. The detailed information and expected changes for all the dependent variables are included in Appendix 12.

Table 35. Regressors coefficients for PSV 700 m^2 deck 5yo - SHP

	a) PSV 4,000 dwt TC Rate	b) AHTS 80t BP TC Rate	c) Laid-Up Vessels: OSV Total	d) Fleet > FPSO Conversions
Coefficient	⇧ 0.448	⇧ 0.286	⇩ -0.052	⇩ -0.269
Independent Variables	**%**	**%**	**%**	**%**
1) Assumed Independent Variable Increment	10	10	10	10
2) PSV 3,200 dwt TC Rate - **Dependent Variable change**	4.5 %	2.9 %	-0.5 %	-2.7 %

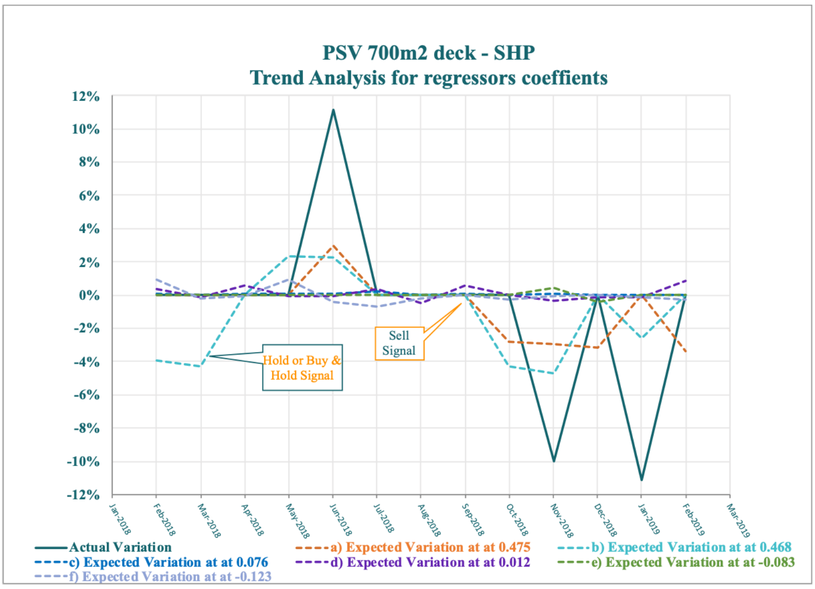
Note: 1) Independent variable increments of 10% on each independent variables are estimated values to test the influence of each of the regressors to the dependent variable.

2) Expected change on average of the value of the dependent variable by a 10% of increment on each of the independent variables, where regressors a) and b) presented the highest influence.

Based on the coefficients, it can be determined which of the regressors have the most influence on the dependent variable, and therefore the ones that are required to be monitored rigorously. A closer inspection of Figure 37 shows early information on a *hold* or *buy & hold* signal of the analysed dependent variable in early March 2018 with an actual peak of the asset in June 2018. The contrary can be observed for September 2018 where an early *Sell* Signal anticipated a drop in the second-hand price, which started to materialize in October 2018 and reached the lowest around November 2018.

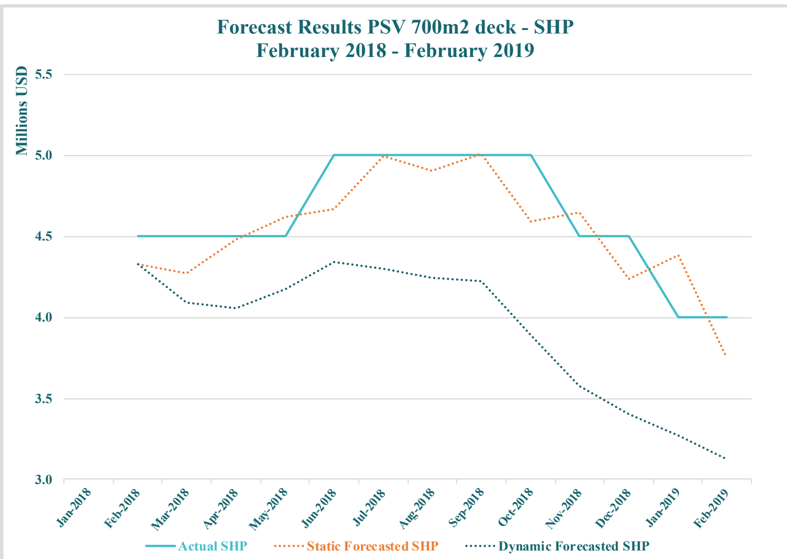
The previous analysis requires the support of the actual forecast (Figure 38) created for the specific variable, which help the trader to envisage and actual timing to execute a selected strategy. For this specific case an increment of 11% (from \$m 4.5 to \$m 5) of the asset SHP and a transaction (selling) window of approximately three months before a strong downturn of the price, was anticipated. These results should be interpreted with caution as the actual situation of the market and the invest and divest timing vary among regions and are also influenced by multiple factors such as vessel inspections and other technical-related issues.

***Figure 37*. Trend analysis for PSV 700 m² deck SHP dependent and regressors**



Note: Actual variation is the variation in % of the second-hand price as reported by Clarksons Research (2019). The letters correspond to the influence of the regressors to the dependent variables based on the model coefficient and the actual variation of the independent variables: a) AHTS 12,000 bhp 5yo – SHP, b) PSV 800m² deck 5yo – SHP, c) PSV 750-899m² TC Rates, GOM, d) PSV 500-899m² Spot, North Sea, e) AHTS 18,000 bhp TC Rates, Brazil and f) AHTS 12,000 bhp TC Rates, S.E Asia

***Figure 38*. Forecast for PSV 700 m² deck SHP From Feb 2018 to Feb 2019**



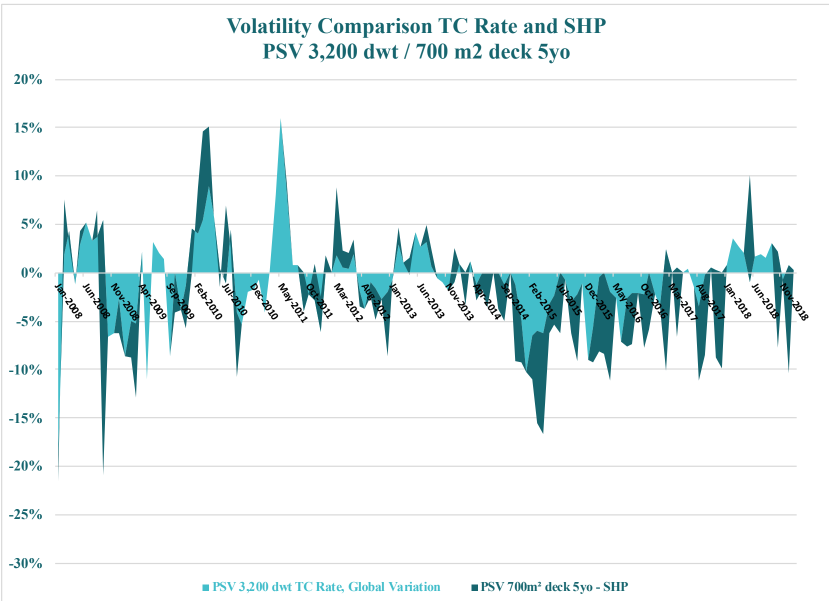
Similar to the T/C rates presented in section 5.1.1., volatility is an additional component to take into consideration when planning or analysing S&P alternatives. Volatility cluster phenomenon is also observed in the SHP (Table 36) market for this specific type of vessel, and no leverage effect is present. Figure 39 present a comparison of the monthly variation of T/C rate and second-hand price for PSV 3,200 dwt / 700 m^2 deck area. It can be observed from the graph that the maximum monthly increment of the T/C rate is around 16% and for the SHP is less than 10%. This information is vital since the historical increments are not very high, and hence this needs to be considered when deciding to go for a long term or short-term contracts strategy. All graphs comparing variables volatility is presented in Appendix 13.

Table 36. Volatility description for regression PSV 700 m^2 deck 5yo - SHP

OLS_ Name	Description	R-Squared	α	ɣ	β
Regression					
*D_LOG_A4_PSV_2_SHP	PSV 5yo 700m2 deck - SHP	0.667	-0.055 (0.146)	0.008 (0.892)	1.071 (0.000)

Note: (α) is lagged squared residual - ARCH term, (ɣ) is asymmetry term and (β) is lagged conditional variance – GARCH(-1) term. Parentheses (.) are p-values, and * is dependent variable.

Figure 39. **Volatility PSV 3,200 dwt / 700 m^2 deck area**



Note: Data retrieved from Clarksons OIN database circa July 2019

The present results are significant in at least two major aspects. First, the presented strategies may be used by charterers and shipowners in order to define possible future scenarios and plan accordingly, either by anticipating upcoming operational costs of OSV services or chasing markets with higher performance and hence higher revenues. Secondly, the mutual interrelation of the variables is relevant since the information exchange from different markets brings regional information to a global perspective, creating a link between different types of vessels and helping to anticipate events.

6 Conclusion

The aim of this study was to examine market strategies for S&P and Term Contracts of different segments of the OSV shipping market. This was achieved through the combination of variables of the offshore O&G operational model, reliable datasets for industry factors and econometric tools, in addition to the evaluation of different approaches to support OSV chartering or investment/divestment decisions. OLS ARMA GARCH models were utilized to analyse the presence of volatility clusters and volatility leverage in PSVs and AHTS in terms of second-hand prices and T/C rates, and to determine the actual relationship between the different factors involved in the offshore O&G operational cycles that influence the OSV market. Further, this study contributes to research and the industry by identifying benchmark variables and the influential factors in the OSV T/C rates and second-hand price dynamics from a global standpoint.

The theoretical framework developed in this study and the empirical findings from the models, provide a better understanding of how valuable market information from different variables, is transmitted through the offshore operational elements identified in the framework. The Spot Rate of PSV in the North Sea, Global T/C rates for PSVs, AHTS 12,000 bhp second-hand price are critical factors for the OSV industry. However, in contrast to some of the expected results, the Crude Oil Price and Global Oil Production are not explanatory variables in seven of the eight models built. The actual influence of these essential variables to the T/C rates and second-hand price in the OSV global market would be a fruitful area for further research.

The multiple regression analysis revealed that in terms of actual market strategies for chartering, and based on the comparison between the actual return scenario and the forecasted returns, the one-year Term Contract presented better performance than the other assessed option of fixing shorter contracts. This is significant and a useful approach to determine markets of interest, and when pursuing Long-Term Contracts or chartering vessels from a global perspective.

The uncertainty of the duration between fixing short contracts, when no earnings are made, places pressure on the T/C rates required for following contracts. A one-year forecast generated for all the dependent variables found that the required monthly T/C rate increments was not going to be sufficiently met in terms of value. This monthly increments was also found to not have been met over the past 10 years either.

The second aim of this study was to investigate second-hand price dynamics to determine S&P opportunities and timings based on econometric analyses and forecasts. *hold* or *buy and hold* signals were detected by analysing the behaviour of the regressors according to the calculated coefficients in the models. Timings and estimated second-hand prices were achieved by producing and analysing forecasts. It was found that under the actual market conditions for the forecasted period, the extent of bullish market windows is limited with durations of around three to four months before the second-hand price (SHP) drops to previous or even lower levels. Hence the difficulty and risk in seeking profits based on projected SHP increments.

On the other hand, the volatility leverage effect is only present in one of the eight examined variables (*PSV 4,000 dwt T/C Rates*). Volatility cluster phenomenon was observed in all T/C rates and SHP except *AHTS 12,000 bhp WAFR* and *AHTS 7,000 bhp 5yo – SHP* where no strong arguments were found to determine volatility, these results are of significance for trader or charterers to project future organizational decisions.

A limitation of this study was the absence of monthly data before January 2008 for some of the variables initially identified in the theoretical framework and consequently it was necessary to reduce the number of observations. This information would be significant in capturing market information before the world financial crisis of 2008. The scope of this study was limited in terms of the quantity of regression built (eight in total). Regressions with regional information of each individual type of vessel deployed on the main offshore regions are also necessary, and further studies could assess, in addition to a global analysis of the market of this study, the regional behaviour to compare market performances and determine regional influential strength to the global overview. The spot market in regions like the North Sea has valuable information when understanding Term Contract segment.

It is also worth highlighting that oil companies' (charterers) profile and its expenditure behaviour must be considered in further studies as it is well known that new expenditure trends and the simplifications of the offshore operation is now the driver of oil companies after the 2014 oil crisis. This certainly impact derived services such as OSV shipping and logistics. The inclusion of quantitative information such as timing, values and number of tender processes would be essential information for the definition of strategies in the OSV market.

Two trends that might strongly influence the OSV sector in terms of T/C rates and second-hand price are envisaged. Firstly, the world trend to reduce CO2 emissions is showing solid signs of continuity with the increment of new offshore windfarms. Secondly, the future decommissioning phase of the oil and gas offshore facilities, where a large amount of vessels will be required. These types of information should be monitored, gathered and included in future models.

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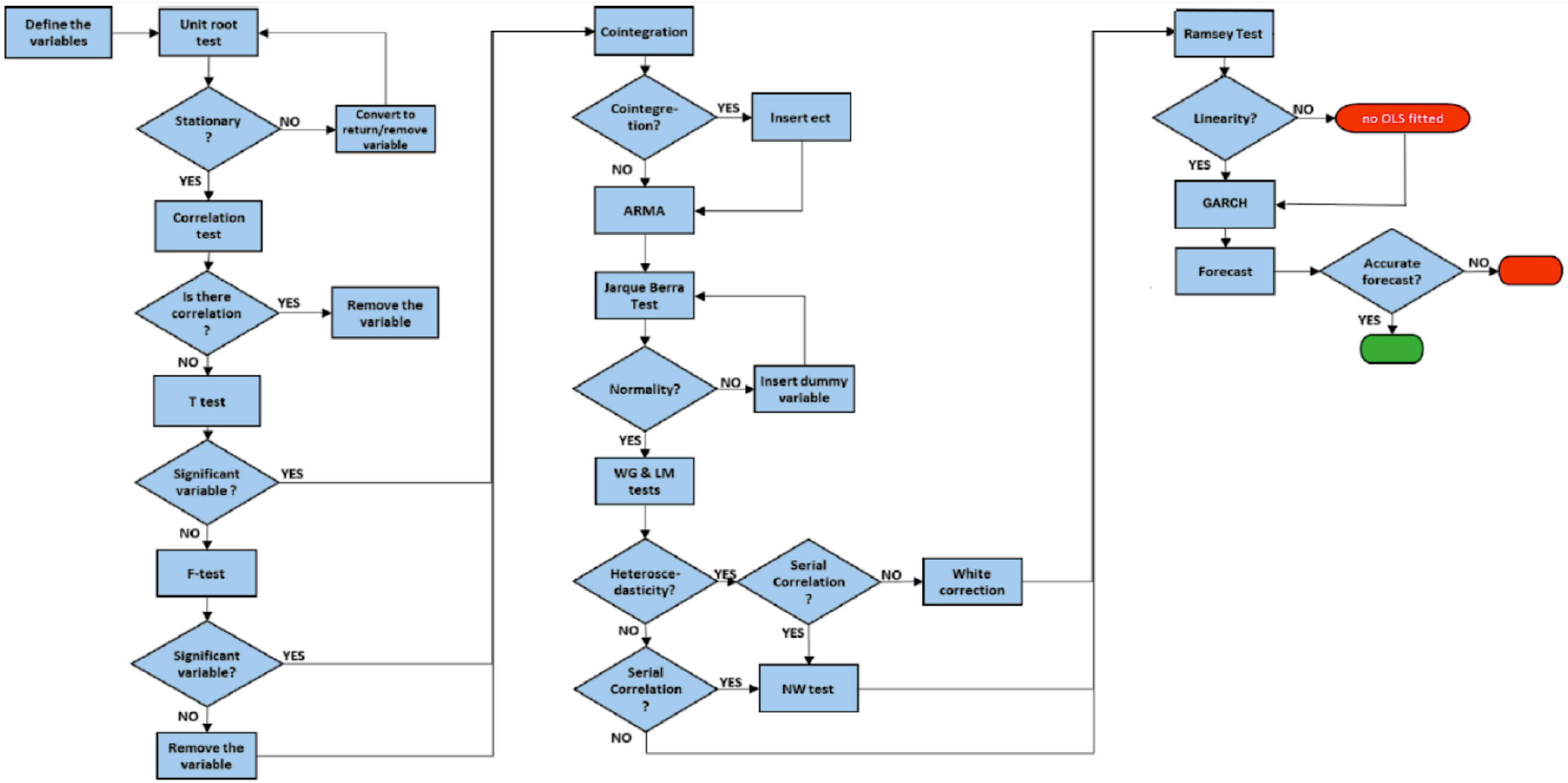
Appendices

Appendix 1

OLS Model from. Adapted from Sahoo, S. (2019). *Model for OLS - WMU MGM 101 class handout notes.* Unpublished manuscript.



Appendix 2

Correlation Test Results

	AB_11	AB_12	AB_13	AB_14	AB_15	AC_11	AC_12	AC_14	AC_15	AC_16	AC_17	AC_18	AC_19	AC_20	AC_21	AC_22	AD_10	AD_11	AD_14	AD_15	AD_16	AD_17	AD_18	AD_19	AD_22	AD_24	AD_25	AD_27	AE_10	AE_11	AE_13	AE_17	AE_18	AE_20	AF_10	AF_11	AF_12	AG_11	AG_12	AG_13	AG_14	AG_15
AB_11	1																																									
AB_12	-0.11	1																																								
AB_13	-0.01	-0.06	1																																							
AB_14	-0.10	0.71	0.02	1																																						
AB_15	-0.11	0.10	-0.01	0.16	1																																					
AC_11	0.02	-0.19	-0.05	-0.12	0.18	1																																				
AC_12	-0.10	0.05	0.14	0.08	0.09	0.11	1																																			
AC_14	0.03	0.05	-0.07	0.23	0.20	0.16	0.00	1																																		
AC_15	0.10	-0.09	0.03	0.12	0.23	0.27	0.09	0.29	1																																	
AC_16	-0.24	0.19	-0.01	0.10	0.19	0.17	0.54	0.19	0.10	1																																
AC_17	0.20	-0.09	-0.01	0.11	0.14	0.38	0.04	0.18	0.42	0.01	1																															
AC_18	0.04	0.24	-0.08	0.40	0.23	0.19	0.04	0.08	0.20	-0.10	0.26	1																														
AC_19	-0.05	0.34	-0.28	0.39	0.05	0.16	-0.05	0.07	0.12	0.10	0.11	0.23	1																													
AC_20	-0.18	0.36	-0.10	0.33	0.19	-0.12	-0.11	0.03	0.05	0.07	-0.14	0.23	0.63	1																												
AC_21	0.25	-0.13	0.00	0.10	0.05	0.44	0.07	0.20	0.38	0.05	0.68	0.15	0.15	-0.03	1																											
AC_22	-0.06	0.17	-0.13	0.25	0.17	0.25	0.10	0.00	0.22	0.16	0.10	0.21	0.74	0.53	0.21	1																										
AD_10	-0.05	0.18	0.08	0.12	0.11	0.15	0.45	0.13	0.10	0.70	0.01	-0.03	0.08	0.06	-0.02	0.09	1																									
AD_11	0.01	-0.03	0.08	-0.06	0.09	0.09	-0.19	0.15	0.13	-0.10	0.21	-0.04	0.03	0.02	0.20	-0.04	-0.12	1																								
AD_14	0.00	-0.04	-0.19	-0.03	-0.03	0.11	-0.21	0.08	-0.08	0.00	-0.12	0.04	0.07	0.04	0.07	0.01	-0.04	-0.04	1																							
AD_15	0.11	0.21	0.07	0.31	0.40	0.19	0.09	0.16	0.26	0.12	0.34	0.33	0.41	0.39	0.28	0.50	0.13	-0.03	-0.02	1																						
AD_16	-0.12	0.27	-0.21	0.38	0.12	0.12	0.02	0.09	0.17	0.12	0.04	0.25	0.75	0.65	0.16	0.79	0.05	0.00	-0.01	0.45	1																					
AD_17	-0.10	0.03	-0.21	0.05	-0.04	0.08	-0.11	0.07	-0.11	0.05	-0.08	0.09	0.09	0.08	0.11	0.07	-0.02	0.00	0.72	0.01	0.03	1																				
AD_18	0.06	-0.06	-0.06	0.02	0.04	-0.05	0.09	-0.32	0.05	0.02	0.05	0.11	-0.01	0.11	0.12	-0.02	-0.01	-0.11	-0.03	0.02	0.04	-0.11	1																			
AD_19	0.06	0.01	0.07	-0.01	0.09	0.06	0.16	0.05	0.04	0.10	0.13	0.00	0.01	-0.08	0.18	0.08	0.10	0.02	-0.41	0.13	0.07	-0.39	-0.04	1																		
AD_22	0.11	0.13	-0.09	0.07	-0.12	-0.05	-0.04	0.05	0.07	-0.06	0.03	0.02	0.11	0.05	-0.02	0.10	-0.09	0.09	0.04	-0.01	0.11	0.19	-0.16	0.10	1																	
AD_24	0.00	0.11	-0.12	0.04	0.08	0.01	0.10	-0.18	-0.05	0.07	-0.05	0.10	0.05	0.17	-0.03	0.13	0.10	-0.17	-0.01	0.06	0.08	-0.09	0.67	0.05	-0.07	1																
AD_25	0.02	0.05	0.10	0.02	0.13	0.04	0.13	-0.02	0.09	0.04	0.21	0.00	0.07	-0.01	0.18	0.15	0.02	0.01	-0.34	0.20	0.11	-0.23	-0.05	0.80	0.20	0.01	1															
AD_27	-0.15	-0.01	-0.18	-0.02	0.02	0.03	-0.02	0.04	-0.02	0.16	-0.19	0.05	0.06	0.08	0.00	0.06	0.00	-0.10	0.69	0.09	0.03	0.79	-0.01	-0.47	-0.01	-0.02	-0.28	1														
AE_10	0.13	0.00	-0.08	-0.28	0.02	-0.17	-0.12	-0.12	-0.26	0.01	-0.29	-0.23	-0.10	-0.01	-0.26	-0.03	0.01	0.05	-0.14	-0.18	-0.04	-0.14	0.05	0.03	-0.02	0.22	0.01	-0.09	1													
AE_11	-0.17	-0.12	-0.07	-0.05	-0.04	0.22	0.11	-0.05	0.03	0.15	0.17	-0.02	0.05	-0.10	0.14	0.04	0.20	0.10	0.04	-0.11	0.01	0.28	-0.27	-0.05	-0.02	-0.33	0.03	0.07	-0.14	1												
AE_13	-0.04	-0.07	0.14	0.21	0.25	0.05	-0.02	0.04	0.21	-0.16	0.22	0.18	0.05	0.12	0.20	0.14	-0.15	0.11	0.13	0.28	0.04	0.05	0.15	-0.06	-0.16	0.05	-0.08	0.05	-0.16	0.02	1											
AE_17	-0.06	0.24	-0.09	0.31	0.05	0.12	0.02	-0.09	-0.01	-0.07	0.08	0.16	0.18	0.14	0.04	-0.01	0.06	-0.02	-0.14	0.05	0.02	-0.08	-0.01	-0.03	0.04	0.09	0.00	-0.04	-0.08	0.03	0.06	1										
AE_18	0.02	0.17	0.04	0.19	0.05	0.05	0.11	0.02	0.10	0.04	0.09	0.12	0.15	0.17	-0.01	0.07	0.08	-0.13	-0.09	0.24	0.09	-0.03	-0.02	0.13	0.16	0.31	0.22	0.00	0.01	0.03	-0.16	0.16	1									
AE_20	0.06	-0.16	0.05	-0.11	0.15	0.27	-0.13	0.06	0.15	-0.21	0.14	-0.10	0.01	0.03	0.20	0.00	-0.06	0.06	-0.01	0.05	0.01	-0.10	-0.06	-0.10	-0.04	-0.12	-0.06	-0.16	-0.19	0.10	-0.03	0.07	-0.09	1								
AF_10	0.17	0.01	0.02	0.03	0.05	0.16	0.12	0.16	0.12	0.01	0.13	0.14	0.02	0.05	0.02	0.03	0.04	0.02	-0.15	0.12	0.01	-0.10	0.09	0.17	0.02	0.11	0.18	-0.16	-0.09	-0.08	0.01	-0.02	0.12	-0.07	1							
AF_11	-0.20	-0.15	-0.04	-0.12	0.34	0.53	0.17	0.23	0.20	0.35	0.17	0.04	0.15	-0.06	0.22	0.20	0.23	0.13	0.04	0.20	0.10	0.05	-0.04	0.24	-0.02	0.10	0.17	0.11	-0.03	0.16	-0.10	-0.04	0.23	0.10	-0.03	1						
AF_12	-0.05	0.06	-0.11	0.14	0.14	0.42	-0.06	0.29	0.22	-0.04	0.28	0.15	0.27	0.03	0.35	0.14	0.04	0.12	0.06	0.21	0.20	0.09	-0.21	-0.02	0.05	-0.13	-0.04	0.02	-0.18	0.10	0.07	0.20	0.11	0.23	0.07	0.24	1					
AG_11	0.07	0.09	0.11	0.25	0.18	0.28	-0.02	0.16	0.33	-0.06	0.29	0.30	0.15	0.15	0.35	0.23	0.09	0.19	-0.02	0.41	0.24	0.06	0.03	-0.03	-0.09	-0.07	-0.01	0.05	-0.28	0.06	0.33	0.11	-0.06	0.25	-0.03	0.07	0.20	1				
AG_12	0.01	0.09	-0.07	0.17	0.21	0.29	0.07	0.19	0.27	0.29	0.19	0.09	0.25	0.10	0.17	0.31	0.27	-0.09	0.01	0.29	0.30	0.14	-0.01	-0.03	-0.04	-0.02	0.01	0.14	-0.09	0.06	0.10	-0.07	-0.02	0.02	0.10	0.21	0.10	0.30	1			
AG_13	-0.25	0.08	0.02	0.13	0.16	0.28	0.12	0.11	0.00	0.16	-0.02	0.06	0.10	0.04	-0.01	0.13	0.21	-0.01	0.16	0.07	0.17	0.13	0.00	-0.03	-0.12	0.02	-0.02	0.09	-0.12	0.12	0.10	0.07	0.01	0.15	0.05	0.28	0.13	0.28	0.51	1		
AG_14	0.08	0.02	0.03	0.15	0.12	0.14	0.04	0.18	0.30	0.03	0.29	0.12	0.03	-0.05	0.34	0.09	0.13	0.11	-0.06	0.21	0.05	0.06	0.00	0.09	-0.03	-0.06	0.12	0.06	-0.21	0.13	0.27	0.16	-0.12	0.10	0.10	0.10	0.12	0.50	0.42	0.43	1	
AG_15	-0.01	0.08	0.01	0.19	0.20	0.29	0.09	0.21	0.28	0.22	0.22	0.10	0.16	0.03	0.24	0.25	0.26	-0.01	0.03	0.28	0.22	0.14	-0.01	0.01	-0.06	-0.04	0.05	0.13	-0.19	0.12	0.21	0.04	-0.05	0.07	0.10	0.23	0.14	0.46	**0.87**	0.72	0.76	1

Appendix 3

F-Test Results

A1_PSV 4,000 dwt TC Rate, Global Indicator			
Wald Test:			
Equation: EQ10_MAIN			
Test Statis	Value	df	Probability
F-statistic	0.689446	(34, 91)	0.8889
Chi-squar	23.44115	34	0.9132

Null Hypothesis: C(2)= C(3)= C(4)= C(6)= C(7)= C(8)=
C(9)= C(10)= C(11)= C(13)= C(14)= C(16)= C(17)=
C(19)= C(20)= C(22)= C(23)= C(24)= C(25)= C(26)=
C(27)= C(29)= C(30)= C(31)= C(32)= C(33)= C(34)=
C(35)= C(36)= C(37)= C(39)= C(40)= C(41)= C(42)=0

A2_PSV 5yo Price Medium c 800m2 deck			
Wald Test:			
Equation: EQ10_MAIN			
Test Statistic	Value	df	Probability
F-statistic	0.604764	(30, 91)	0.9403
Chi-square	18.14291	30	0.9562

Null Hypothesis: C(2)= C(3)= C(4)= C(6)= C(7)= C(8)=
C(9)= C(10)= C(11)= C(13)= C(15)= C(17)= C(18)=
C(19)= C(22)= C(23)= C(25)= C(26)= C(27)= C(28)=
C(29)= C(30)= C(31)= C(33)= C(35)= C(36)= C(37)=
C(38)= C(39)= C(42)=0

F-Test Results

A3_PSV 3,200 dwt TC Rate, Global Indicator			
Wald Test:			
Equation: EQ10_MAIN			
Test Statistic	Value	df	Probability
F-statistic	0.4564	(29, 91)	0.9907
Chi-square	13.23561	29	0.9946

Null Hypothesis: C(2)= C(3)= C(4)= C(5)= C(6)= C(7)= C(8)= C(9)= C(10)= C(11)= C(13)= C(15)= C(16)= C(18)= C(21)= C(22)= C(24)= C(25)= C(29)= C(30)= C(31)= C(32)= C(33)= C(35)= C(36)= C(37)= C(40)= C(41)= C(42)=0

A4_PSV 5yo Price Medium c 700m2 deck			
Wald Test:			
Equation: EQ10_MAIN			
Test Statistic	Value	df	Probability
F-statistic	0.647361	(30, 91)	0.9113
Chi-square	19.42082	30	0.9308

Null Hypothesis: C(2)= C(3)= C(5)= C(6)= C(8)= C(11)= C(12)= C(13)= C(16)= C(17)= C(18)= C(19)= C(21)= C(23)= C(24)= C(26)= C(27)= C(28)= C(29)= C(30)= C(32)= C(33)= C(34)= C(35)= C(36)= C(38)= C(39)= C(40)= C(41)= C(42)=0

F-Test Results

A5_AHTS Term Charter Rates, WAFR, 12,000 bhp			
Wald Test:			
Equation: EQ10_MAIN			
Test Statistic	Value	df	Probability
F-statistic	0.693092	(36, 91)	0.8914
Chi-square	24.95132	36	0.917

Null Hypothesis: C(2)= C(3)= C(4)= C(8)= C(9)= C(10)= C(12)= C(13)= C(14)= C(15)= C(16)= C(17)= C(18)= C(19)= C(20)= C(21)= C(22)= C(23)= C(24)= C(25)= C(26)= C(27)= C(28)= C(29)= C(30)= C(31)= C(32)= C(34)= C(35)= C(36)= C(37)= C(38)= C(39)= C(40)= C(41)= C(42)=0

A6_AHTS 5yo, Medium 12,000 bhp			
Wald Test:			
Equation: EQ10_MAIN			
Test Statistic	Value	df	Probability
F-statistic	1.048318	(35, 91)	0.4171
Chi-square	36.69112	35	0.3903

Null Hypothesis: C(2)= C(5)= C(6)= C(7)= C(8)= C(9)= C(10)= C(11)= C(12)= C(13)= C(14)= C(16)= C(17)= C(18)= C(19)= C(21)= C(22)= C(23)= C(24)= C(25)= C(26)= C(27)= C(28)= C(29)= C(30)= C(33)= C(34)= C(35)= C(36)= C(37)= C(38)= C(39)= C(40)= C(41)= C(42)=0

F-Test Results

A7_AHTS 80t BP TC Rate, Global Indicator

Wald Test:
Equation: EQ10_MAIN

Test Statistic	Value	df	Probability
F-statistic	0.841463	(25, 91)	0.6801
Chi-square	21.03656	25	0.6906

Null Hypothesis: C(3)= C(4)= C(8)= C(9)= C(10)= C(13)= C(14)= C(15)= C(17)= C(18)= C(19)= C(20)= C(25)= C(26)= C(27)= C(28)= C(29)= C(30)= C(31)= C(32)= C(35)= C(36)= C(38)= C(39)= C(42)=0

A8_AHTS 5yo, Medium 7,000 bhp

Wald Test:
Equation: EQ10_MAIN

Test Statistic	Value	df	Probability
F-statistic	1.490297	(37, 72)	0.0743
Chi-square	55.14099	37	0.0279

Null Hypothesis: C(2)= C(3)= C(4)= C(5)= C(6)= C(8)= C(9)= C(10)= C(11)= C(13)= C(15)= C(16)= C(17)= C(18)= C(19)= C(22)= C(23)= C(24)= C(25)= C(26)= C(27)= C(28)= C(29)= C(30)= C(31)= C(32)= C(33)= C(34)= C(35)= C(36)= C(37)= C(38)= C(39)= C(40)= C(41)= C(42)= C(43)=0

Appendix 4

Cointegration Results

Var. Name	Coefficient	Prob.
Dependent Variable		
A1_PSV 4,000 dwt TC Rate, Global Indicator		
Error Correction Terms		
ECT_AB14(-1)	-0.527	0.785
ECT_AC17(-1)	0.197	0.100
ECT_AC21(-1)	-0.177	0.132
ECT_AD11(-1)	0.195	0.737
ECT_AD16(-1)	0.920	0.031
ECT_AD27(-1)	-0.691	0.729
ECT_AG11(-1)	0.131	0.397

Var. Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A2_PSV_SHP		
Error Correction Terms		
ECT_AB14(-1)	0.335	0.092
ECT_AC22(-1)	0.008	0.938
ECT_AD10(-1)	-0.791	0.364
ECT_AE13(-1)	0.296	0.751
ECT_AE21(-1)	0.147	0.721
ECT_AG13(-1)	0.069	0.812

Variable Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A3_PSV_2_TC		
Error Correction Terms		
ECT_AC18(-1)	0.023	0.895
ECT_AC21(-1)	0.084	0.394
ECT_AD11(-1)	-0.221	0.259
ECT_AD15(-1)	-0.043	0.811
ECT_AD16(-1)	-0.413	0.540
ECT_AD19(-1)	0.480	0.539
ECT_AD25(-1)	-0.612	0.192
ECT_AD27(-1)	0.626	0.025
ECT_AE10(-1)	0.265	0.095
ECT_AE21(-1)	0.020	0.837
ECT_AG11(-1)	-0.078	0.687
ECT_AG12(-1)	0.030	0.904

Cointegration Results

Variable Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A4_PSV_2_SHP		
Error Correction Terms		
ECT_AC14(-1)	-4.034	0.068
ECT_AF12(-1)	-0.631	0.452
ECT_AC21(-1)	-0.137	0.638
ECT_AB13(-1)	-0.072	0.949
ECT_AC15(-1)	-0.041	0.893
ECT_AD16(-1)	0.103	0.335
ECT_AC11(-1)	0.692	0.050
ECT_AD18(-1)	0.993	0.358
ECT_AD24(-1)	1.212	0.063
ECT_AE17(-1)	1.939	0.230

Variable Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A5_AHTS_TC		
Significant Independet Variables		
ECT_AC11(-1)	-0.905	0.152
ECT_AC16(-1)	-0.303	0.581
ECT_AB14(-1)	-0.039	0.876
ECT_AB15(-1)	-0.034	0.926
ECT_AE20(-1)	1.352	0.039

Var. Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A6_AHTS_SHP		
Error Correction Terms		
ECT_AB12(-1)	-0.226	0.263
ECT_AB13(-1)	0.633	0.003
ECT_AC22(-1)	-0.068	0.580
ECT_AD16(-1)	-0.112	0.372
ECT_AE17(-1)	-0.031	0.917
ECT_AE18(-1)	-0.293	0.217
Note: Result after dropping non-significant ECT;		
ECT_AE18(-1)	-0.038	0.499

Cointegration Results

Variable Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A7_AHTS_2_TC		
Significant Independet Variables		
ECT_AD22(-1)	-3.445707	0.407
ECT_AC11(-1)	-1.522279	0.022
ECT_AB14(-1)	-0.49875	0.331
ECT_AB15(-1)	-0.429669	0.934
ECT_AE20(-1)	-0.299493	0.331
ECT_AC17(-1)	-0.043552	0.735
ECT_AF12(-1)	0.006132	0.972
ECT_AE21(-1)	0.080099	0.534
ECT_AG13(-1)	0.161153	0.835
ECT_AD19(-1)	0.310269	0.391
ECT_AG14(-1)	0.447644	0.014
ECT_AB11(-1)	0.468621	0.074
ECT_AD10(-1)	0.873343	0.365
ECT_AD17(-1)	1.09836	0.102
ECT_AD18(-1)	1.212487	0.051
ECT_AC16(-1)	1.805321	0.791

Note: Result after dropping non-significant ECT; ECT_AB14(-1) -0.652172 0.0912 ECT_AC11(-1) 0.769432 0.0444

Variable Name	Coefficient	Prob.
Dependent Variable		
D_LOG_A8_AHTS_2_SHP		
Significant Independet Variables		
ECT_AC11(-1)	0.65742	0.244
ECT_AC17(-1)	-0.619192	0.231
ECT_AC19(-1)	0.154789	0.360
ECT_AD15(-1)	-0.210559	0.336
ECT_AD16(-1)	-0.061485	0.714

Appendix 5

ARMA Process Results

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		-0.001	0.746
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	-0.115	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	0.164	0.001
D_LOG_AD_11	North America- Total Drillships Utilisation	1.040	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.216	0.000
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	0.121	0.017
AR(1)		-0.514	0.000
MA(1)		0.869	0.000
MA(2)		-0.131	0.016

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck		
C		0.002	0.584
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.084	0.048
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.279	0.009
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.254	0.006
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.514	0.000
D_LOG_AD_17	Fleet > Mobile Production	-1.219	0.051
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.236	0.005
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	-0.071	0.039
AR(1)		1.650	0.000
AR(2)		-0.826	0.000
MA(1)		-1.759	0.000
MA(2)		0.892	0.000

ARMA Process Results

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A3_PSV_2_	PSV 3,200 dwt TC Rate, Global Indicator		
C		0.007	0.050
Significant Independet Variables			
D_LOG_AC_18	AHTS Term Charter Rates, WAFR, 12,000 bhp	0.104	0.000
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.115	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.258	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.169	0.000
D_LOG_AD_27	Fleet > FPSO Conversions	-0.559	0.000
D_LOG_AE_10	Laid-Up Vessels, Global: Total OSVs	-0.064	0.006
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.500	0.013
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	-0.153	0.022
D_LOG_AG_12	Global Avg Floater Dayrate, Ultra	0.080	0.060
MA(1)		0.642	0.000

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A4_PSV_2_SHP	PSV 5yo Price Medium c 700m2 deck		
C		-0.082	0.048
Significant Independet Variables			
D_LOG_AB_13	Global Oil Prod.	0.687	0.030
D_LOG_AC_14	AHTS Term Charter Rates Brazil, 18,000 b	-0.128	0.002
D_LOG_AC_15	PSV Term Charter Rates, US Gulf, 750-89	0.099	0.041
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.524	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.172	0.048
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.471	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Su	-0.108	0.000
D_LOG_AD_24	Orderbook > Mobile Production > Semi-Su	0.087	0.001
D_LOG_AE_17	Middle East/ISC- Total Floaters Utilisation	-0.067	0.006
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia	-0.127	0.021
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.009	0.050
AR(1)		1.641	0.000
AR(2)		-0.881	0.000
MA(1)		-1.713	0.000
MA(2)		0.946	0.000

ARMA Process Results

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A5_AHTS_T	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.167	0.000
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.246	0.000
D_LOG_AB_15	PSV/Supply Orderbook	0.187	0.006
D_LOG_AC_16	South America-Active No of Floaters	-0.283	0.000
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.075	0.000
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.018	0.001
AR(1)		0.626	0.000
AR(2)		-0.911	0.000
MA(1)		-0.541	0.000
MA(2)		1.157	0.000

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A6_AHTS_SHP	AHTS 5yo, Medium 12,000 bhp		
C		-0.004	0.106
Significant Independet Variables			
D_LOG_AB_12	Brent Crude Oil Price	0.064	0.010
D_LOG_AB_13	Global Oil Prod.	-0.809	0.008
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.347	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.253	0.001
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	0.101	0.001
AR(1)		-0.982	0.000
AR(2)		-0.899	0.000
MA(1)		1.058	0.000
MA(2)		0.962	0.000

ARMA Process Results

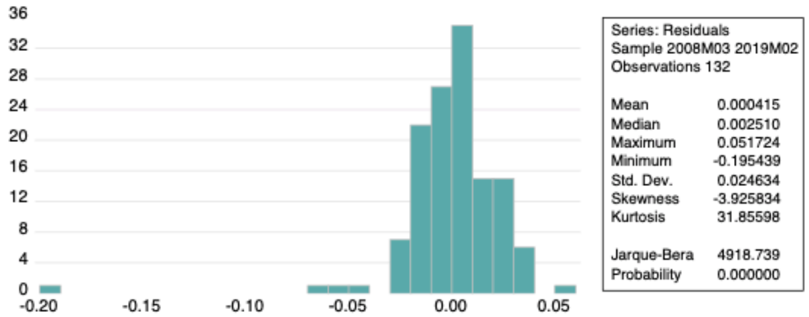
Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2	AHTS 80t BP TC Rate, Global Indicator		
C		-0.131	0.001
Significant Independet Variables			
D_LOG_AB_11	LIBOR Interest Rates	0.050	0.023
D_LOG_AC_16	South America-Active No of Floaters	0.169	0.004
D_LOG_AD_10	South America-Active No of Drillships	-0.154	0.000
D_LOG_AD_17	Fleet > Mobile Production	1.744	0.001
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Submersil	0.057	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.100	0.001
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.244	0.000
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12,00	0.145	0.001
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.166	0.003
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.247	0.001
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.013	0.001
AR(1)		-0.472	0.001
MA(1)		0.852	0.000

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A8_AHTS_2_SH	AHTS 7,000 bhp 5yo, - SHP		
C		0.117	0.004
Significant Independet Variables			
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.157	0.095
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.514	0.000
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.325	0.009
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.284	0.004
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	-0.013	0.004
AR(1)		0.808	0.000
MA(1)		-0.977	0.000

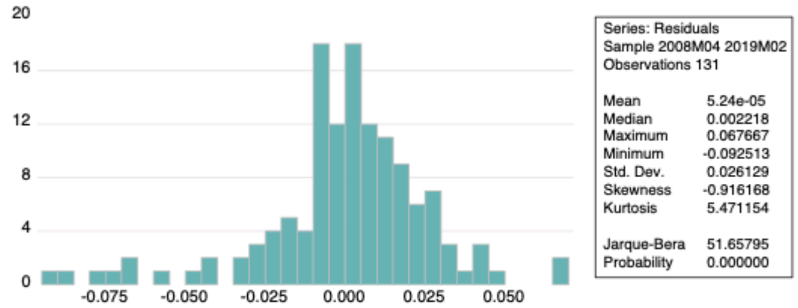
Appendix 6

Jarque Berra – Normality Test Results

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		-0.001	0.746
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	-0.115	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	1.040	0.000
D_LOG_AD_11	North America- Total Drillships Utilisation	-0.216	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	1.040	0.017
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	0.164	0.001
AR(1)		-0.514	0.000
MA(1)		0.869	0.000
MA(2)		-0.131	0.016

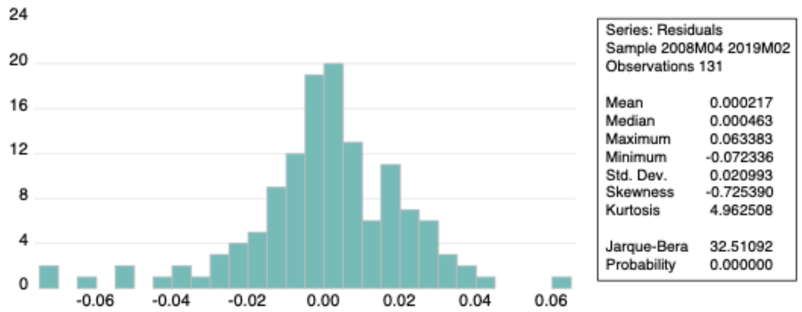


Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck		
C		0.002	0.584
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.084	0.048
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.279	0.009
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.254	0.006
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.514	0.000
D_LOG_AD_17	Fleet > Mobile Production	-1.219	0.051
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.236	0.005
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	-0.071	0.039
AR(1)		1.650	0.000
AR(2)		-0.826	0.000
MA(1)		-1.759	0.000
MA(2)		0.892	0.000

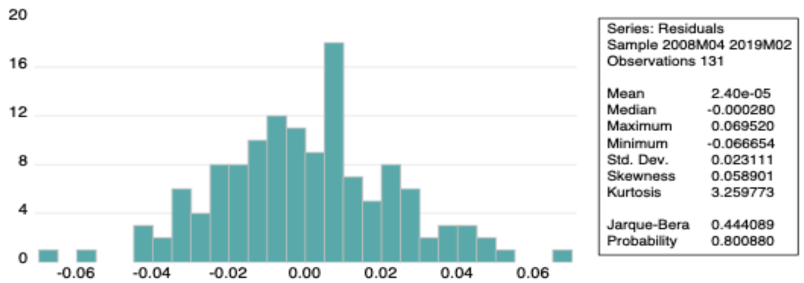


Jarque Berra – Normality Test Results

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator		
C		0.009	0.007
Significant Independent Variables			
D_LOG_AC_18	AHTS Term Charter Rates, WAFR, 12,000 bhp	0.104	0.000
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.115	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.258	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.169	0.000
D_LOG_AD_27	Fleet > FPSO Conversions	-0.559	0.000
D_LOG_AE_10	Laid-Up Vessels, Global: Total OSVs	-0.064	0.006
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.500	0.013
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	-0.153	0.022
D_LOG_AG_12	Global Avg Floater Dayrate, Ultra	0.080	0.060
MA(1)		0.642	0.000

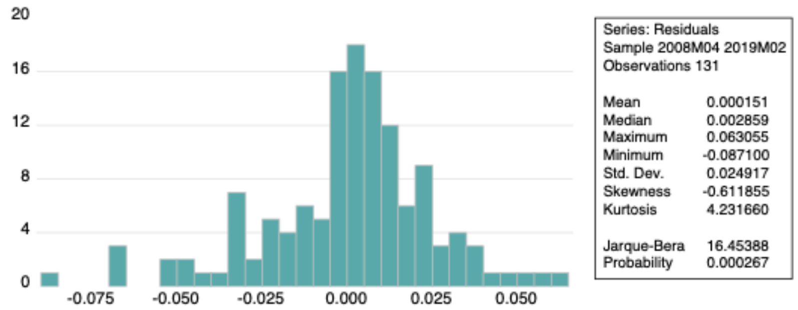


OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A4_PSV_2_SHI	PSV 5yo Price Medium c 700m2 deck		
C		-0.082	0.048
Significant Independent Variables			
D_LOG_AB_13	Global Oil Prod.	0.741	0.014
D_LOG_AC_14	AHTS Term Charter Rates Brazil, 18,000 bhp	-0.132	0.001
D_LOG_AC_15	PSV Term Charter Rates, US Gulf, 750-899m²	0.097	0.036
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.550	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.158	0.057
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.472	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Subm	-0.102	0.000
D_LOG_AD_24	Orderbook > Mobile Production > Semi-Subm	0.084	0.001
D_LOG_AE_17	Middle East/ISC- Total Floaters Utilization	-0.072	0.002
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12	-0.108	0.033
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.009	0.043
_2014_01_01		0.092	0.000
AR(1)		1.627	0.000
AR(2)		-0.861	0.000
MA(1)		-1.715	0.000
MA(2)		0.946	0.000

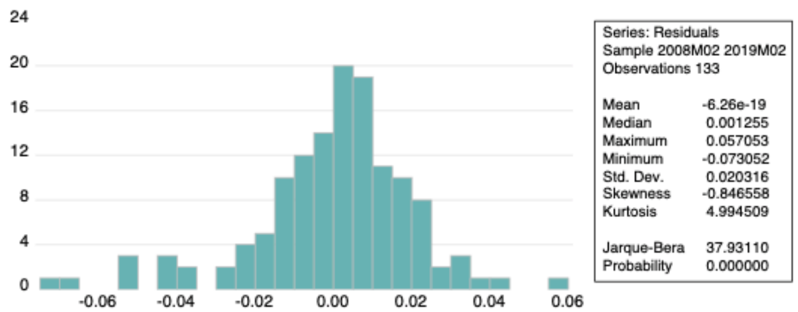


Jarque Berra – Normality Test Results

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.167	0.000
Significant Independent Variables			
D_LOG_AB_14	MGO Bunker Price	0.246	0.000
D_LOG_AB_15	PSV/Supply Orderbook	0.187	0.006
D_LOG_AC_16	South America-Active No of Floaters	-0.283	0.000
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.075	0.000
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.018	0.001
AR(1)		0.626	0.000
AR(2)		-0.911	0.000
MA(1)		-0.541	0.000
MA(2)		1.157	0.000

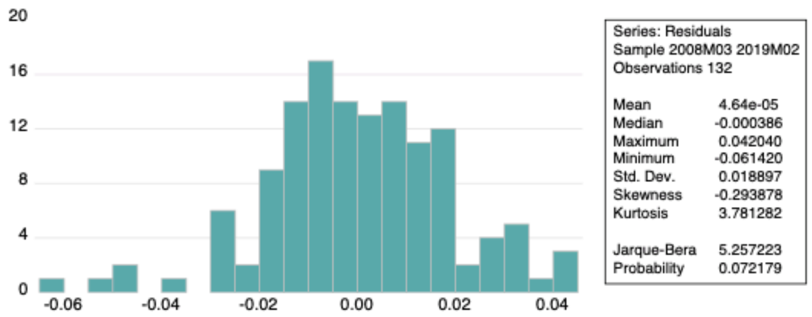


Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A6_AHTS_SHP	AHTS 5yo, Medium 12,000 bhp		
C		-0.004	0.106
Significant Independent Variables			
D_LOG_AB_12	Brent Crude Oil Price	0.064	0.010
D_LOG_AB_13	Global Oil Prod.	-0.809	0.008
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.347	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.253	0.001
D_LOG_AE_18	North Sea- 3500-10000 ft Utilization	0.101	0.001
AR(1)		-0.982	0.000
AR(2)		-0.899	0.000
MA(1)		1.058	0.000
MA(2)		0.962	0.000

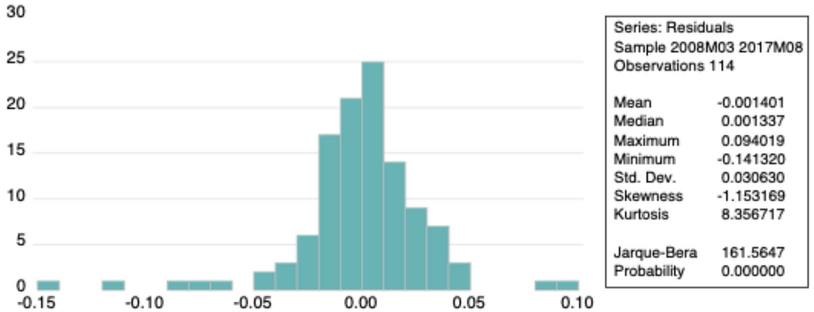


Jarque Berra – Normality Test Results

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2_T	AHTS 80t BP TC Rate, Global Indicator		
C		-0.131	0.001
Significant Independent Variables			
D_LOG_AB_11	LIBOR Interest Rates	0.050	0.023
D_LOG_AC_16	South America-Active No of Floaters	0.169	0.004
D_LOG_AD_10	South America-Active No of Drillships	-0.154	0.000
D_LOG_AD_17	Fleet > Mobile Production	1.744	0.001
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Subm	0.057	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.100	0.001
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.244	0.000
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12	0.145	0.001
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.166	0.003
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.247	0.001
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.013	0.001
AR(1)		-0.472	0.001
MA(1)		0.852	0.000



Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A8_AHTS_2_SHI	AHTS 5yo, Medium 7,000 bhp		
C		0.117	0.004
Significant Independet Variables			
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.157	0.095
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.514	0.000
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.325	0.009
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.284	0.004
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	-0.013	0.004
AR(1)		0.808	0.000
MA(1)		-0.977	0.000



Appendix 7

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - PSV 4,000 dwt TC Rate, Global Indicator			
Regression Code			
D_LOG_A1_PSV_TC			
Heteroskedasticity (White-Test)			
F-statistic	1.431	Prob. F(51,80)	0.075
Obs*R-squared	62.968	Prob. Chi-Square(51	0.121
Scaled explained SS	835.806	Prob. Chi-Square(51	0.000
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	1.127086	Prob. F(14,109)	0.343
Obs*R-squared	16.69233	Prob. Chi-Square(14	0.273

No. Corr

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		-0.001	0.746
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	-0.115	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	1.040	0.000
D_LOG_AD_11	North America- Total Drillships Utilisation	-0.216	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	1.040	0.017
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	0.164	0.001
AR(1)		-0.514	0.000
MA(1)		0.869	0.000
MA(2)		-0.131	0.016

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - PSV 5yo Price Medium c 800m2 deck			
Regression Code			
D_LOG_A2_PSV_SHP			
Heteroskedasticity (White-Test)			
F-statistic	0.812	Prob. F(90,40)	0.792
Obs*R-squared	84.677	Prob. Chi-Square(90)	0.639
Scaled explained SS	155.951	Prob. Chi-Square(90)	0.000
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	1.260093	Prob. F(14,105)	0.245
Obs*R-squared	18.84366	Prob. Chi-Square(14)	0.171

No. Corr

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck		
C		0.002	0.584
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.084	0.048
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.279	0.009
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.254	0.006
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.514	0.000
D_LOG_AD_17	Fleet > Mobile Production	-1.219	0.051
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.236	0.005
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	-0.071	0.039
AR(1)		1.650	0.000
AR(2)		-0.826	0.000
MA(1)		-1.759	0.000
MA(2)		0.892	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - PSV 3,200 dwt TC Rate, Global Indicator			
Regression Code			
D_LOG_A3_PSV_2_TC			
Heteroskedasticity (White-Test)			
F-statistic	5.134	Prob. F(77,55)	0.000
Obs*R-squared	116.755	Prob. Chi-Square(77)	0.002
Scaled explained SS	191.961	Prob. Chi-Square(77)	0.000
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	2.184	Prob. F(14,108)	0.013
Obs*R-squared	29.345	Prob. Chi-Square(14)	0.009

N-W Correction

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator		
C		0.005	0.142
Significant Independet Variables			
D_LOG_AC_18	AHTS Term Charter Rates, WAFR, 12,000 bhp	0.100	0.032
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.223	0.002
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.102	0.005
D_LOG_AD_27	Fleet > FPSO Conversions	-0.465	0.037
D_LOG_AE_10	Laid-Up Vessels, Global: Total OSVs	-0.067	0.000
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.501	0.000
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	-0.136	0.039
D_LOG_AG_12	Global Avg Floater Dayrate, Ultra	0.082	0.048
MA(1)		0.683	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - PSV 5yo Price Medium c 700m2 deck			
Regression Code			
D_LOG_A4_PSV_2_SH P			
Heteroskedasticity (White-Test)			
F-statistic	1.541	Prob. F(119,12)	0.204
Obs*R-squared	123.891	Prob. Chi-Square(119)	0.361
Scaled explained SS	135.447	Prob. Chi-Square(119)	0.144
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	1.312891	Prob. F(14,104)	0.213
Obs*R-squared	19.82525	Prob. Chi-Square(14)	0.136

No. Corr

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A4_PSV_2_SH	PSV 5yo Price Medium c 700m2 deck		
C		-0.082	0.048
Significant Independet Variables			
D_LOG_AB_13	Global Oil Prod.	0.741	0.014
D_LOG_AC_14	AHTS Term Charter Rates Brazil, 18,000 bhp	-0.132	0.001
D_LOG_AC_15	PSV Term Charter Rates, US Gulf, 750-899m²	0.097	0.036
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.550	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.158	0.057
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.472	0.000
D_LOG_AD_18	Orderbook > Mobile Production >SS Prod.	-0.102	0.000
D_LOG_AD_24	Orderbook > Mobile Production > SS Prod.	0.084	0.001
D_LOG_AE_17	Middle East/ISC- Total Floaters Utilisation	-0.072	0.002
D_LOG_AF_12	AHTS TC Rates, South East Asia, 12,000 bhp	-0.108	0.033
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.009	0.043
_2014_01_01		0.092	0.000
AR(1)		1.627	0.000
AR(2)		-0.861	0.000
MA(1)		-1.715	0.000
MA(2)		0.946	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - AHTS 12,000 bhp Term Charter Rates - Global			
Regression Code			
D_LOG_A5_AHTS_TC			
Heteroskedasticity (White-Test)			
F-statistic	1.721	Prob. F(27,103)	0.028
Obs*R-squared	40.725	Prob. Chi-Square(27)	0.044
Scaled explained SS	54.185	Prob. Chi-Square(27)	0.001
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	4.041	Prob. F(14,107)	0.000
Obs*R-squared	45.308	Prob. Chi-Square(14)	0.000

N-W Correction

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.167	0.007
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.246	0.000
D_LOG_AB_15	PSV/Supply Orderbook	0.187	0.006
D_LOG_AC_16	South America-Active No of Floaters	-0.283	0.000
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.075	0.012
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.018	0.008
AR(1)		0.626	0.000
AR(2)		-0.911	0.000
MA(1)		-0.541	0.000
MA(2)		1.157	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - AHTS 12,000 bhp 5yo - SHP			
Regression Code			
D_LOG_A6_AHTS_SHP			
Heteroskedasticity (White-Test)			
F-statistic	0.877	Prob. F(90,22)	0.701
Obs*R-squared	61.205	Prob. Chi-Square(90	0.611
Scaled explained SS	74.020	Prob. Chi-Square(90	0.208
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	1.014	Prob. F(14,87)	0.445
Obs*R-squared	15.342	Prob. Chi-Square(14	0.355

No. Corr

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A6_AHTS_SH	AHTS 5yo, Medium 12,000 bhp		
C		-0.004	0.106
Significant Independet Variables			
D_LOG_AB_12	Brent Crude Oil Price	0.064	0.010
D_LOG_AB_13	Global Oil Prod.	-0.809	0.008
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.347	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.253	0.001
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	0.101	0.001
AR(1)		-0.982	0.000
AR(2)		-0.899	0.000
MA(1)		1.058	0.000
MA(2)		0.962	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - AHTS 80t BP TC Rate, Global Indicator			
Regression Code			
D_LOG_A7_AHTS_2_TC			
Heteroskedasticity (White-Test)			
F-statistic	3.392	Prob. F(119,12)	0.011
Obs*R-squared	128.189	Prob. Chi-Square(11	0.266
Scaled explained SS	142.308	Prob. Chi-Square(11	0.072
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	0.812969	Prob. F(14,104)	0.654
Obs*R-squared	13.02085	Prob. Chi-Square(14	0.525

White Correction

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2_T	AHTS 80t BP TC Rate, Global Indicator		
C		-0.131	0.000
Significant Independet Variables			
D_LOG_AB_11	LIBOR Interest Rates	0.050	0.053
D_LOG_AC_16	South America-Active No of Floaters	0.169	0.009
D_LOG_AD_10	South America-Active No of Drillships	-0.154	0.000
D_LOG_AD_17	Fleet > Mobile Production	1.744	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Submers	0.057	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.100	0.002
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.244	0.000
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12,(	0.145	0.000
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.166	0.000
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.247	0.005
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.013	0.001
AR(1)		-0.472	0.004
MA(1)		0.852	0.000

Heteroskedasticity and Serial Correlation Tests (White - Newey-West Corrections)

OLS_ Name - AHTS 7,000 bhp 5yo - SHP			
Regression Code			
D_LOG_A8_AHTS_2_SHP			
Heteroskedasticity (White-Test)			
F-statistic	2.332	Prob. F(44,69)	0.001
Obs*R-squared	68.163	Prob. Chi-Square(44	0.011
Scaled explained SS	222.327	Prob. Chi-Square(44	0.000
Breusch-Godfrey Serial Correlation LM Test (14 Lags)			
F-statistic	0.75734	Prob. F(14,92)	0.711
Obs*R-squared	11.78053	Prob. Chi-Square(14	0.624

White Correction

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A8_AHTS_2_S	AHTS 5yo, Medium 7,000 bhp		
C		-0.001	0.013
Significant Independet Variables			
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.157	0.066
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.514	0.002
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.325	0.068
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.284	0.008
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	-0.013	0.012
AR(1)		0.808	0.000
MA(1)		-0.977	0.000

Appendix 8

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator		
C		-0.001	0.746
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	-0.115	0.001
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	1.040	0.000
D_LOG_AD_11	North America- Total Drillships Utilisation	-0.216	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	1.040	0.017
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	0.164	0.001
AR(1)		-0.514	0.000
MA(1)		0.869	0.000
MA(2)		-0.131	0.016

Null hypothesis: the model is linear

Ramsey RESET Test

Equation: A1_PSV 4,000 dwt TC Rate, Global Indicator
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A1_PSV_TC C D_LOG_AB_14 D_LOG_AG_11
D_LOG_AC_17 D_LOG_AD_11 D_LOG_AD_16 AR(1) MA(1) MA(2

	Value	df	Probability
F-statistic	22.230	(2, 121)	0.000
Likelihood ratio	41.308	2.000	0.000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001	0.002	0.480	0.632
D_LOG_AB_14	-0.035	0.033	-1.053	0.294
D_LOG_AG_11	0.139	0.060	2.303	0.023
D_LOG_AC_17	0.590	0.070	8.394	0.000
D_LOG_AD_11	-0.117	0.069	-1.679	0.096
D_LOG_AD_16	0.081	0.046	1.768	0.080
FITTED^2	-1.062	0.589	-1.804	0.074
FITTED^3	43.854	5.804	7.555	0.000
AR(1)	-0.095	0.276	-0.344	0.731
MA(1)	0.122	0.290	0.423	0.673
MA(2)	-0.135	0.093	-1.460	0.147

Ramsey Reset Test

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck		
C		0.002	0.584
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.084	0.048
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.279	0.009
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.254	0.006
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.514	0.000
D_LOG_AD_17	Fleet > Mobile Production	-1.219	0.051
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.236	0.005
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	-0.071	0.039
AR(1)		1.650	0.000
AR(2)		-0.826	0.000
MA(1)		-1.759	0.000
MA(2)		0.892	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A2_PSV 5yo Price Medium c 800m2 deck
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A2_PSV_SHP C D_LOG_AB_14 D_LOG_AC_17 D_LOG_AC_19 D_LOG_AC_22 D_LOG_AD_17 D_LOG_AE_21 AR(1) AR(2) MA(1) MA(2) D_LOG_AE_18

	Value	df	Probability
F-statistic	5.89893	(2, 117)	0.0036
Likelihood ratio	12.585	2.000	0.002

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.001	0.003	-0.367	0.714
D_LOG_AB_14	0.072	0.038	1.865	0.065
D_LOG_AC_17	-0.174	0.100	-1.744	0.084
D_LOG_AC_19	0.173	0.096	1.798	0.075
D_LOG_AC_22	0.460	0.072	6.363	0.000
D_LOG_AD_17	-1.142	0.597	-1.914	0.058
D_LOG_AE_21	0.190	0.075	2.530	0.013
D_LOG_AE_18	-0.045	0.033	-1.337	0.184
FITTED^2	1.646	2.402	0.685	0.495
FITTED^3	11.428	7.696	1.485	0.140
AR(1)	1.009	0.372	2.713	0.008
AR(2)	-0.452	0.287	-1.575	0.118
MA(1)	-1.054	0.387	-2.722	0.008
MA(2)	0.383	0.337	1.138	0.257

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator		
C		0.005	0.142
Significant Independet Variables			
D_LOG_AC_18	AHTS Term Charter Rates, WAFR, 12,000 bhp	0.100	0.032
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.223	0.002
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	-0.102	0.005
D_LOG_AD_27	Fleet > FPSO Conversions	-0.465	0.037
D_LOG_AE_10	Laid-Up Vessels, Global: Total OSVs	-0.067	0.000
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.501	0.000
D_LOG_AG_11	Global Avg Jack-Up Dayrate, All	-0.136	0.039
D_LOG_AG_12	Global Avg Floater Dayrate, Ultra	0.082	0.048
MA(1)		0.683	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A3_PSV 3,200 dwt TC Rate, Global Indicator
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A3_PSV_2_TC C D_LOG_AE_21 D_LOG_AE_10 D_LOG_AD_27 D_LOG_AC_21 D_LOG_AD_16 D_LOG_AG_11 D_LOG_AC_18 D_LOG_AG_12 MA(1)

	Value	df	Probability
F-statistic	0.195	(2, 121)	0.823
Likelihood ratio	0.428	2.000	0.807

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.006	0.003	1.877	0.063
D_LOG_AE_21	0.490	0.074	6.585	0.000
D_LOG_AE_10	-0.065	0.014	-4.602	0.000
D_LOG_AD_27	-0.449	0.232	-1.936	0.055
D_LOG_AC_21	0.229	0.075	3.037	0.003
D_LOG_AD_16	-0.104	0.040	-2.640	0.009
D_LOG_AG_11	-0.130	0.063	-2.063	0.041
D_LOG_AC_18	0.099	0.048	2.088	0.039
D_LOG_AG_12	0.082	0.041	1.982	0.050
FITTED^2	-0.641	2.091	-0.306	0.760
FITTED^3	-2.699	15.347	-0.176	0.861
MA(1)	0.686	0.098	6.988	0.000

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A4_PSV_2_SH	PSV 5yo Price Medium c 700m2 deck		
C		-0.080	0.041
Significant Independet Variables			
D_LOG_AB_13	Global Oil Prod.	0.741	0.014
D_LOG_AC_14	AHTS Term Charter Rates Brazil, 18,000 bhp	-0.132	0.001
D_LOG_AC_15	PSV Term Charter Rates, US Gulf, 750-899m²	0.097	0.036
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.550	0.000
D_LOG_AC_21	AHTS 80t BP TC Rate, Global Indicator	0.158	0.057
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.472	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Subme	-0.102	0.000
D_LOG_AD_24	Orderbook > Mobile Production > Semi-Subme	0.084	0.001
D_LOG_AE_17	Middle East/ISC- Total Floaters Utilisation	-0.072	0.002
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12	-0.108	0.033
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.009	0.043
_2014_01_01		0.092	0.000
AR(1)		1.627	0.000
AR(2)		-0.861	0.000
MA(1)		-1.715	0.000
MA(2)		0.946	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation:A4_PSV 5yo Price Medium c 700m2 deck
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A4_PSV_2_SHP C D_LOG_AC_19 D_LOG_A
D_LOG_AD_18 D_LOG_AD_24 D_LOG_AC_14 D_LOG_AE_
D_LOG_AC_21 D_LOG_AC_15 D_LOG_AF_12 D_LOG_AB_1
LOG_AC_11 AR(1) MA(1) _2014_01_01

	Value	df	Probability
F-statistic	0.245	(2, 115)	0.783
Likelihood ratio	0.561	2.000	0.756

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.113	0.048	-2.369	0.020
D_LOG_AC_19	0.548	0.089	6.168	0.000
D_LOG_AD_16	0.439	0.081	5.393	0.000
D_LOG_AD_18	-0.105	0.027	-3.884	0.000
D_LOG_AD_24	0.090	0.025	3.535	0.001
D_LOG_AC_14	-0.133	0.039	-3.440	0.001
D_LOG_AE_17	-0.072	0.025	-2.908	0.004
D_LOG_AC_21	0.140	0.081	1.721	0.088
D_LOG_AC_15	0.099	0.049	2.001	0.048
D_LOG_AF_12	-0.118	0.058	-2.058	0.042
D_LOG_AB_13	0.664	0.313	2.119	0.036
LOG_AC_11	0.012	0.005	2.328	0.022
_2014_01_01	0.088	0.026	3.376	0.001
FITTED^2	1.133	1.666	0.680	0.498
FITTED^3	3.706	5.305	0.699	0.486
AR(1)	0.787	0.293	2.684	0.008
MA(1)	-0.790	0.298	-2.648	0.009

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp		
C		-0.167	0.007
Significant Independet Variables			
D_LOG_AB_14	MGO Bunker Price	0.246	0.000
D_LOG_AB_15	PSV/Supply Orderbook	0.187	0.006
D_LOG_AC_16	South America-Active No of Floaters	-0.283	0.000
D_LOG_AE_20	UK-Active No of Jack-Ups	-0.075	0.012
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.018	0.008
AR(1)		0.626	0.000
AR(2)		-0.911	0.000
MA(1)		-0.541	0.000
MA(2)		1.157	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A5_AHTS Term Charter Rates, WAFR, 12,000 bhp
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A5_AHTS_TC C D_LOG_AC_16 D_LOG_AB_14
LOG_AC_11 D_LOG_AE_20 D_LOG_AB_15 AR(1) MA(1) AR(2) MA(

	Value	df	Probability
F-statistic	35.034	(2, 119)	0.000
Likelihood ratio	60.651	2.000	0.000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.074	0.050	-1.474	0.143
D_LOG_AC_16	-0.067	0.052	-1.280	0.203
D_LOG_AB_14	0.043	0.069	0.627	0.532
LOG_AC_11	0.008	0.006	1.518	0.132
D_LOG_AE_20	-0.058	0.027	-2.113	0.037
D_LOG_AB_15	0.054	0.057	0.935	0.352
FITTED^2	0.020	3.376	0.006	0.995
FITTED^3	252.142	53.245	4.735	0.000
AR(1)	-0.406	0.049	-8.308	0.000
AR(2)	-0.874	0.058	-15.199	0.000
MA(1)	0.471	0.083	5.686	0.000
MA(2)	1.187	0.164	7.225	0.000

Ramsey Reset Test

Variable Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A6_AHTS_SH	AHTS 5yo, Medium 12,000 bhp		
C		-0.004	0.106
Significant Independendet Variables			
D_LOG_AB_12	Brent Crude Oil Price	0.064	0.010
D_LOG_AB_13	Global Oil Prod.	-0.809	0.008
D_LOG_AC_22	PSV 5yo Price Medium c 700m2 deck	0.347	0.000
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.253	0.001
D_LOG_AE_18	North Sea- 3500-10000 ft Utilisation	0.101	0.001
AR(1)		-0.982	0.000
AR(2)		-0.899	0.000
MA(1)		1.058	0.000
MA(2)		0.962	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A6_AHTS 5yo, Medium 12,000 bhp
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A6_AHTS_SHP C D_LOG_AC_22 D_LOG_AD_16 D_LOG_AE_18 D_LOG_AB_13 D_LOG_AB_12 AR(1) AR(2) MA(1) MA(2)

	Value	df	Probability	
F-statistic	5.463	(2, 119)	0.005	
Likelihood ratio	11.508	2.000	0.003	
C	-0.005132	0.002688	-1.909436	0.0586
D_LOG_AC_22	0.30014	0.070021	4.286397	0
D_LOG_AD_16	0.152	0.081	1.872	0.064
D_LOG_AE_18	0.114	0.028	4.047	0.000
D_LOG_AB_13	-0.710	0.284	-2.499	0.014
D_LOG_AB_12	0.038	0.026	1.498	0.137
FITTED^2	-0.235	2.324	-0.101	0.920
FITTED^3	6.159	8.429	0.731	0.466
AR(1)	-0.985	0.037	-26.875	0.000
AR(2)	-0.899	0.036	-24.643	0.000
MA(1)	1.090	0.026	42.040	0.000
MA(2)	0.960	0.022	44.511	0.000

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A7_AHTS_2_T	AHTS 80t BP TC Rate, Global Indicator		
C		-0.131	0.000
Significant Independet Variables			
D_LOG_AB_11	LIBOR Interest Rates	0.050	0.053
D_LOG_AC_16	South America-Active No of Floaters	0.169	0.009
D_LOG_AD_10	South America-Active No of Drillships	-0.154	0.000
D_LOG_AD_17	Fleet > Mobile Production	1.744	0.000
D_LOG_AD_18	Orderbook > Mobile Production > Semi-Subme	0.057	0.000
D_LOG_AD_19	Orderbook > Mobile Production > FPSO	0.100	0.002
D_LOG_AE_21	PSV 4,000 dwt TC Rate, Global Indicator	0.244	0.000
D_LOG_AF_12	AHTS Term Charter Rates, South East Asia, 12	0.145	0.000
D_LOG_AG_13	Global Avg Floater Dayrate, Deep	-0.166	0.000
D_LOG_AG_14	Global Avg Floater Dayrate, Mid	0.247	0.005
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	0.013	0.001
AR(1)		-0.472	0.004
MA(1)		0.852	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A7_AHTS 80t BP TC Rate, Global Indicator
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A7_AHTS_2_TC C D_LOG_AD_17 D_LOG_A
D_LOG_AD_10 D_LOG_AE_21 LOG_AC_11 D_LOG_AB_11
D_LOG_AD_18 D_LOG_AC_16 D_LOG_AF_12 D_LOG_AG_
D_LOG_AG_14 AR(1) MA(1)

	Value	df	Probability
F-statistic	0.069	(2, 116)	0.933
Likelihood ratio	0.157	2.000	0.925

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.130	0.038	-3.389	0.001
D_LOG_AD_17	1.787	0.467	3.823	0.000
D_LOG_AD_19	0.098	0.031	3.139	0.002
D_LOG_AD_10	-0.157	0.039	-4.066	0.000
D_LOG_AE_21	0.248	0.081	3.056	0.003
LOG_AC_11	0.013	0.004	3.149	0.002
D_LOG_AB_11	0.052	0.028	1.835	0.069
D_LOG_AD_18	0.056	0.014	4.090	0.000
D_LOG_AC_16	0.178	0.074	2.415	0.017
D_LOG_AF_12	0.144	0.034	4.306	0.000
D_LOG_AG_13	-0.172	0.044	-3.855	0.000
D_LOG_AG_14	0.242	0.085	2.837	0.005
FITTED^2	-0.848	2.275	-0.373	0.710
FITTED^3	-6.949	22.026	-0.315	0.753
AR(1)	-0.483	0.161	-2.998	0.003
MA(1)	0.852	0.099	8.619	0.000

Ramsey Reset Test

OLS_ Name	Description	Coefficient.	Prob.
Dependent Variable			
D_LOG_A8_AHTS_2_S	AHTS 5yo, Medium 7,000 bhp		
C		-0.001	0.013
Significant Independet Variables			
D_LOG_AC_17	PSV 3,200 dwt TC Rate, Global Indicator	-0.157	0.066
D_LOG_AC_19	AHTS 5yo, Medium 12,000 bhp	0.514	0.002
D_LOG_AD_15	PSV Resale Price Medium c 700m2 deck	0.325	0.068
D_LOG_AD_16	PSV 5yo Price Medium c 800m2 deck	0.284	0.008
LOG_AC_11	PSV Spot Rate, North Sea, 500-899m²	-0.013	0.012
AR(1)		0.808	0.000
MA(1)		-0.977	0.000

Null hypothesis: the model is linear

Ramsey RESET Test
Equation: A8_AHTS 5yo, Medium 7,000 bhp
Omitted Variables: Powers of fitted values from 2 to 3
Specification: D_LOG_A8_AHTS_2_SHP C D_LOG_AC_19
D_LOG_AC_17 LOG_AC_11 D_LOG_AD_15 D_LOG_AD_16 AR(1)
MA(1)

	Value	df	Probability
F-statistic	15.677	(2, 104)	0.000
Likelihood ratio	30.039	2.000	0.000

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.007	0.036	-0.198	0.844
D_LOG_AC_19	0.046	0.121	0.376	0.708
D_LOG_AC_17	-0.109	0.076	-1.437	0.154
LOG_AC_11	0.001	0.004	0.197	0.844
D_LOG_AD_15	0.335	0.146	2.294	0.024
D_LOG_AD_16	-0.025	0.077	-0.324	0.747
FITTED^2	-10.061	8.710	-1.155	0.251
FITTED^3	-20.166	27.893	-0.723	0.471
AR(1)	-0.332	0.966	-0.344	0.732
MA(1)	0.187	0.977	0.191	0.849

Appendix 9

Final ARMA GARCH Models

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A1_PSV_TC		PSV 4,000 dwt TC Rate, Global Indicator	
C	0.000	Constant	0.892
D_LOG_AC_17	0.861	PSV 3,200 dwt TC Rate, Global Indicator	0.000
D_LOG_AD_11	-0.067	North America- Total Drillships Utilisation	0.051
Variance Equation			
C	0.000		0.089
RESID(-1)^2	0.157		0.924
RESID(-1)^2*(RESID(-1)<0)	0.730		0.000
GARCH(-1)	0.654		0.000
R-squared	0.545	Mean dependent var	-0.008
Adjusted R-squared	0.538	S.D. dependent var	0.049
S.E. of regression	0.034	Akaike info criterion	-4.743
Sum squared resid	0.146	Schwarz criterion	-4.591
Log likelihood	322.423	Hannan-Quinn criter.	-4.681
Durbin-Watson stat	1.551		

*Dependent Variable

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A2_PSV_SHP		PSV 5yo Price Medium c 800m2 deck	
C	0.004	Constant	0.160
D_LOG_AB_14	0.065	MGO Bunker Price	0.041
D_LOG_AC_17	-0.291	PSV 3,200 dwt TC Rate, Global Indicator	0.004
D_LOG_AC_19	0.422	AHTS 5yo, Medium 12,000 bhp	0.000
D_LOG_AC_22	0.427	PSV 5yo Price Medium c 700m2 deck	0.000
D_LOG_AD_17	-0.895	Fleet > Mobile Production	0.037
D_LOG_AE_21	0.285	PSV 4,000 dwt TC Rate, Global Indicator	0.000
Variance Equation			
C	0.001		0.000
RESID(-1)^2	0.754		0.000
RESID(-1)^2*(RESID(-1)<0)	-0.556		0.001
GARCH(-1)	-0.171		0.000
R-squared	0.622	Mean dependent var	-0.014
Adjusted R-squared	0.604	S.D. dependent var	0.047
S.E. of regression	0.029	Akaike info criterion	-4.295
Sum squared resid	0.109	Schwarz criterion	-4.056
Log likelihood	296.613	Hannan-Quinn criter.	-4.198
Durbin-Watson stat	1.821		

Final GARCH Models

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A3_PSV_2_TC		PSV 3,200 dwt TC Rate, Global Indicator	
C	0.005	Constant	0.052
D_LOG_AC_21	0.286	AHTS 80t BP TC Rate, Global Indicator	0.000
D_LOG_AD_27	-0.269	Fleet > FPSO Conversions	0.016
D_LOG_AE_10	-0.052	Laid-Up Vessels, Global: Total OSVs	0.000
D_LOG_AE_21	0.448	PSV 4,000 dwt TC Rate, Global Indicator	0.000
MA(1)	0.499		0.000
Variance Equation			
C	0.000		0.001
RESID(-1)^2	0.476		0.004
RESID(-1)^2*(RESID(-1)<0)	-0.572		0.000
GARCH(-1)	0.639		0.000
R-squared	0.703	Mean dependent var	-0.007
Adjusted R-squared	0.691	S.D. dependent var	0.042
S.E. of regression	0.023	Akaike info criterion	-5.056
Sum squared resid	0.070	Schwarz criterion	-4.838
Log likelihood	346.201	Hannan-Quinn criter.	-4.967
Durbin-Watson stat	2.154		

*Dependent Variable

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A4_PSV_2_SHP		PSV 5yo Price Medium c 700m2 deck	
C	-0.113	Constant	0.001
D_LOG_AC_14	-0.083	AHTS Term Charter Rates Brazil, 18,000 bh	0.034
D_LOG_AC_15	0.076	PSV Term Charter Rates, US Gulf, 750-899	0.037
D_LOG_AC_19	0.475	AHTS 5yo, Medium 12,000 bhp	0.000
D_LOG_AD_16	0.468	PSV 5yo Price Medium c 800m2 deck	0.000
D_LOG_AF_12	-0.123	AHTS Term Charter Rates, South East Asia,	0.055
LOG_AC_11	0.012	PSV Spot Rate, North Sea, 500-899m^2	0.001
AR(1)	0.840		0.000
MA(1)	-0.796		0.000
Variance Equation			
C	0.000		0.802
RESID(-1)^2	-0.055		0.146
RESID(-1)^2*(RESID(-1)<0)	0.008		0.892
GARCH(-1)	1.071		0.000
R-squared	0.667	Mean dependent var	-0.016
Adjusted R-squared	0.645	S.D. dependent var	0.048
S.E. of regression	0.029	Akaike info criterion	-4.421
Sum squared resid	0.101	Schwarz criterion	-4.137
Log likelihood	304.767	Hannan-Quinn criter.	-4.305
Durbin-Watson stat	2.084		

Final ARMA GARCH Models

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A5_AHTS_TC		AHTS 12,000 bhp TC Rates, WAFR	
C	-0.006	Constant	0.076
D_LOG_AB_14	0.196	MGO Bunker Price	0.000
D_LOG_AB_15	0.291	PSV/Supply Orderbook	0.000
D_LOG_AC_16	-0.183	South America-Active No of Floaters	0.007
D_LOG_AE_20	-0.076	UK-Active No of Jack-Ups	0.000
AR(1)	0.558		0.000
AR(2)	-0.897		0.000
MA(1)	-0.419		0.000
MA(2)	1.000		0.000
Variance Equation			
C	0.000		0.061
RESID(-1)^2	0.494		0.132
RESID(-1)^2*(RESID(-1)<0)	-0.228		0.429
GARCH(-1)	0.292		0.256
R-squared	0.317	Mean dependent var	-0.006
Adjusted R-squared	0.272	S.D. dependent var	0.039
S.E. of regression	0.033	Akaike info criterion	-3.939
Sum squared resid	0.136	Schwarz criterion	-3.654
Log likelihood	271.005	Hannan-Quinn criter.	-3.823
Durbin-Watson stat	2.009		
*Dependent Variable			

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A6_AHTS_SHP		AHTS 5yo, Medium 12,000 bhp	
C	-0.001	Constant	0.603
D_LOG_AB_12	0.081	Brent Crude Oil Price	0.000
D_LOG_AB_13	-0.565	Global Oil Prod.	0.010
D_LOG_AC_22	0.400	PSV 5yo Price Medium c 700m2 deck	0.000
D_LOG_AD_16	0.255	PSV 5yo Price Medium c 800m2 deck	0.000
D_LOG_AE_18	0.096	North Sea- 3500-10000 ft Utilisation	0.000
Variance Equation			
C	0.000		0.000
RESID(-1)^2	0.149		0.052
RESID(-1)^2*(RESID(-1)<0)	-0.285		0.001
GARCH(-1)	0.911		0.000
R-squared	0.622	Mean dependent var	-0.015
Adjusted R-squared	0.607	S.D. dependent var	0.041
S.E. of regression	0.026	Akaike info criterion	-4.512
Sum squared resid	0.086	Schwarz criterion	-4.295
Log likelihood	310.051	Hannan-Quinn criter.	-4.424
Durbin-Watson stat	2.030		

Final ARMA GARCH Models

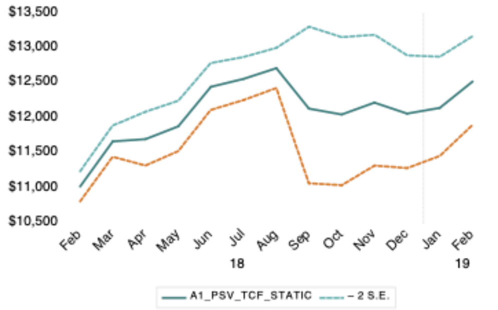
OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A7_AHTS_2_TC		AHTS 80t BP TC Rate, Global Indicator	
C	-0.148		0.000
D_LOG_AC_16	0.242	South America-Active No of Floaters	0.000
D_LOG_AD_10	-0.146	South America-Active No of Drillships	0.000
D_LOG_AD_18	0.054	Orderbook > Mobile Production > SS Prod.	0.000
D_LOG_AE_21	0.261	PSV 4,000 dwt TC Rate, Global Indicator	0.000
D_LOG_AF_12	0.189	AHTS TC Rates, South East Asia, 12,000 b	0.000
LOG_AC_11	0.016	PSV Spot Rate, North Sea, 500-899m²	0.000
AR(1)	-0.230		0.020
MA(1)	0.838		0.000
Variance Equation			
C	0.000		0.035
RESID(-1)^2	1.175		0.022
RESID(-1)^2*(RESID(-1)<0)	-1.073		0.039
GARCH(-1)	0.488		0.000
R-squared	0.499	Mean dependent var	-0.012
Adjusted R-squared	0.466	S.D. dependent var	0.034
S.E. of regression	0.025	Akaike info criterion	-4.795
Sum squared resid	0.075	Schwarz criterion	-4.511
Log likelihood	329.479	Hannan-Quinn criter.	-4.680
Durbin-Watson stat	2.575		
*Dependent Variable			

OLS_ Name	Coefficient.	Description	Prob.
Mean Equation			
*D_LOG_A8_AHTS_2_SHP		AHTS 5yo, Medium 7,000 bhp	
C	0.067	Constant	0.062
D_LOG_AC_19	0.207	AHTS 5yo, Medium 12,000 bhp	0.025
D_LOG_AD_15	0.327	PSV Resale Price Medium c 700m2 deck	0.049
LOG_AC_11	-0.007	PSV Spot Rate, North Sea, 500-899m²	0.001
Variance Equation			
C	0.000		0.316
RESID(-1)^2	10.275		0.502
RESID(-1)^2*(RESID(-1)<0)	-9.356		0.531
GARCH(-1)	0.061		0.327
R-squared	0.282	Mean dependent var	-0.011
Adjusted R-squared	0.263	S.D. dependent var	0.048
S.E. of regression	0.041	Akaike info criterion	-4.240
Sum squared resid	0.186	Schwarz criterion	-4.049
Log likelihood	251.794	Hannan-Quinn criter.	-4.162
Durbin-Watson stat	1.924		

Appendix 10

Forecast Statistics

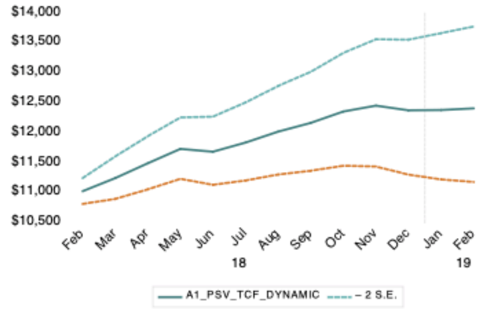
Variable Name	Description
A1_PSV_TC	PSV 4,000 dwt TC Rate, Global Indicator



Forecast: A1_PSV_TCF_STATIC
Actual: A1_PSV_TC
Forecast sample: 2018M02 2019M02
Included observations: 13

Root Mean Squared Error	321.7808
Mean Absolute Error	235.5577
Mean Abs. Percent Error	1.954270
Theil Inequality Coef.	0.013290
Bias Proportion	0.001980
Variance Proportion	0.018170
Covariance Proportion	0.979850
Theil U2 Coefficient	0.935964
Symmetric MAPE	1.955168

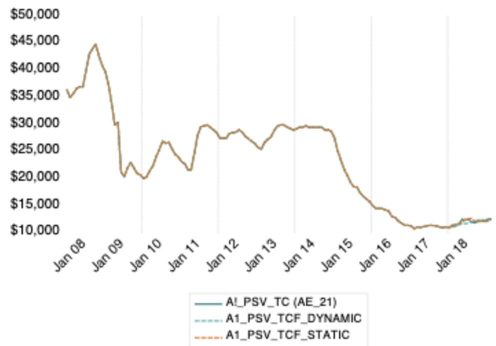
a)



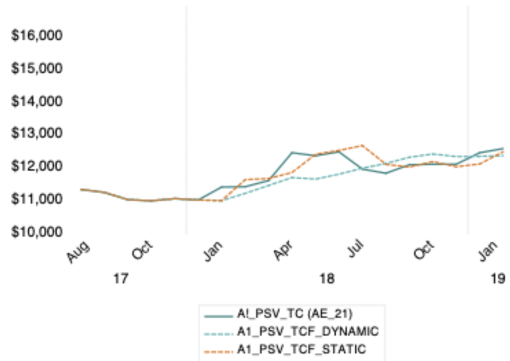
Forecast: A1_PSV_TCF_DYNAMIC
Actual: A1_PSV_TC
Forecast sample: 2018M02 2019M02
Included observations: 13

Root Mean Squared Error	407.5165
Mean Absolute Error	335.9818
Mean Abs. Percent Error	2.755597
Theil Inequality Coef.	0.016937
Bias Proportion	0.167711
Variance Proportion	0.027365
Covariance Proportion	0.804923
Theil U2 Coefficient	1.217104
Symmetric MAPE	2.796360

b)



c)

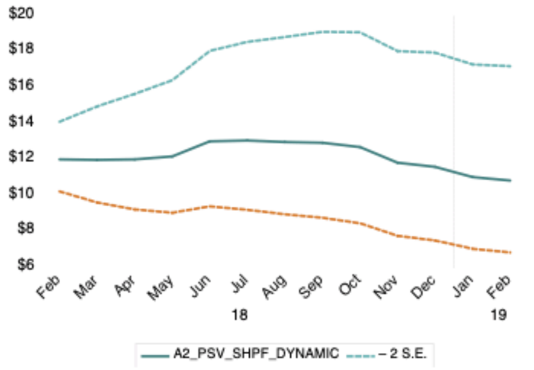


d)

a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Forecast Statistics

Variable Name	Description
A2_PSV_SHP	PSV 5yo Price Medium c 800m2 deck

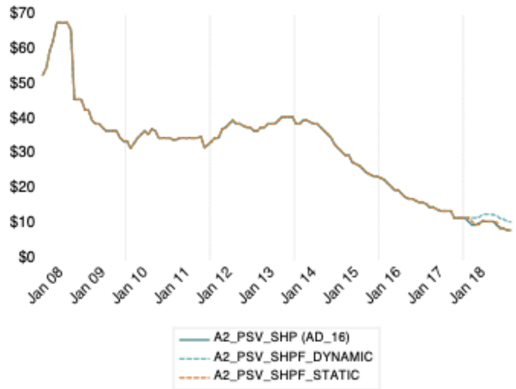


Forecast: A2_PSV_SHPF_DYNAMIC	
Actual: A2_PSV_SHP	
Forecast sample: 2018M02 2019M02	
Included observations: 13	
Root Mean Squared Error	2.187239
Mean Absolute Error	2.137393
Mean Abs. Percent Error	21.80656
Theil Inequality Coef.	0.098170
Bias Proportion	0.954940
Variance Proportion	0.011428
Covariance Proportion	0.033632
Theil U2 Coefficient	4.244303
Symmetric MAPE	19.51593

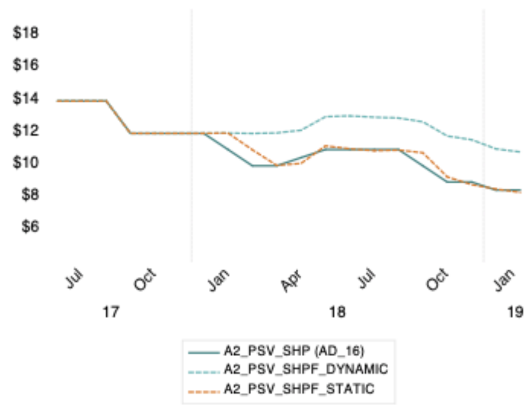
a)

Forecast: A2_PSV_SHPF_STATIC	
Actual: A2_PSV_SHP	
Forecast sample: 2018M02 2019M02	
Included observations: 13	
Root Mean Squared Error	0.478308
Mean Absolute Error	0.326237
Mean Abs. Percent Error	3.221174
Theil Inequality Coef.	0.023463
Bias Proportion	0.182853
Variance Proportion	0.107732
Covariance Proportion	0.709415
Theil U2 Coefficient	0.697820
Symmetric MAPE	3.131989

b)



c)

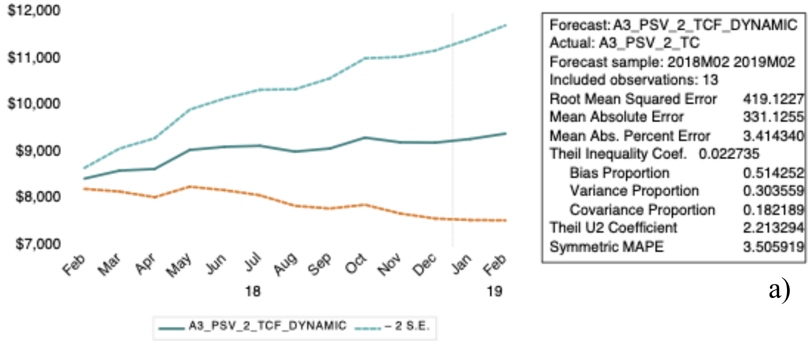


d)

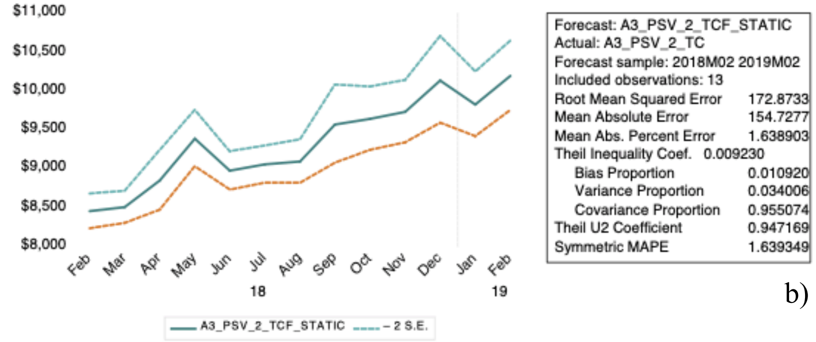
a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Forecast Statistics

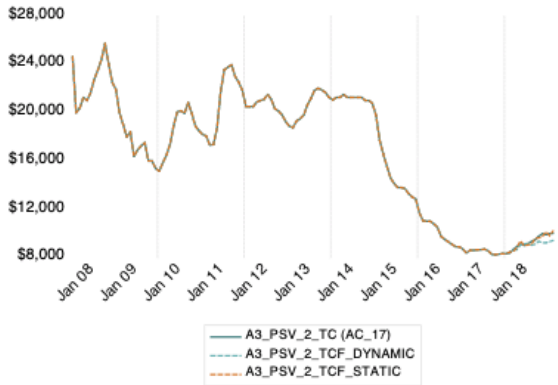
Variable Name	Description
A3_PSV_2_TC	PSV 3,200 dwt TC Rate, Global Indicator



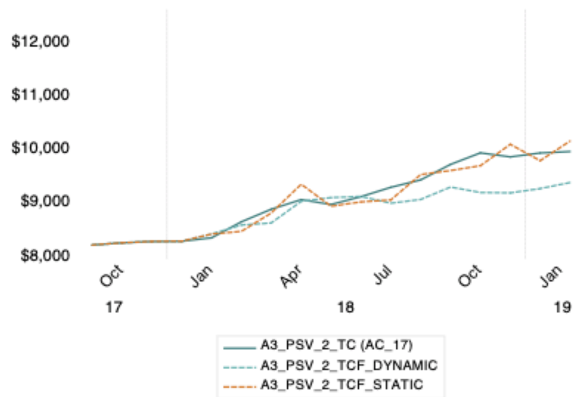
a)



b)



c)

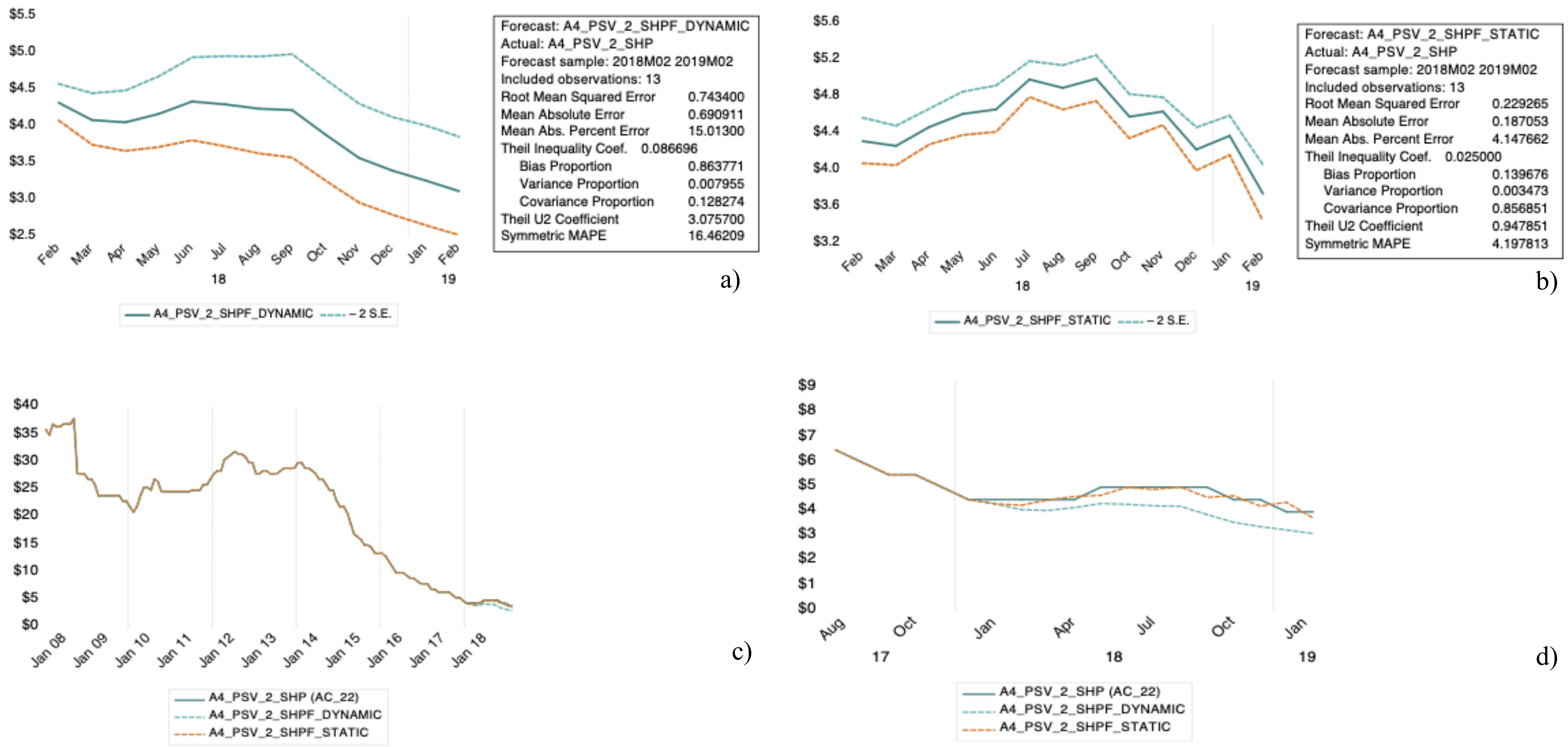


d)

a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Forecast Performance Results

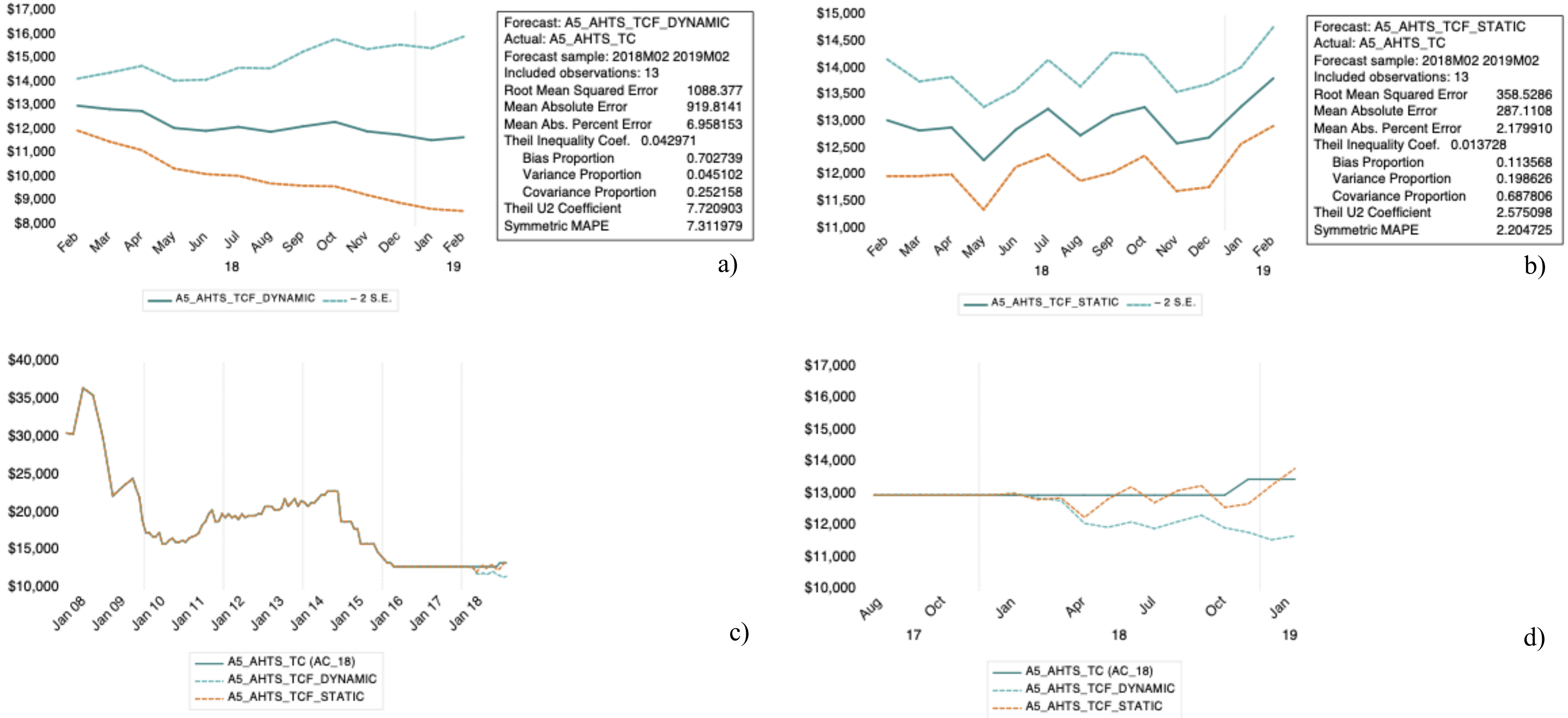
Variable Name	Description
A4_PSV_2_SHP	PSV 5yo Price Medium c 700m2 deck



a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Forecast Performance Results

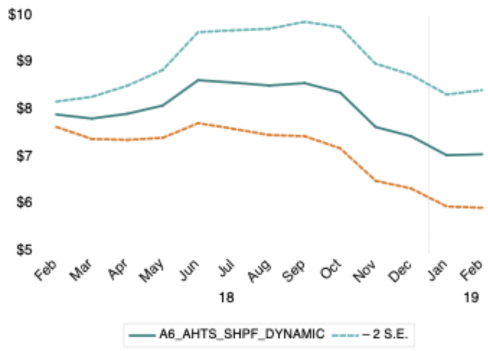
Variable Name	Description
A5_AHTS_TC	AHTS Term Charter Rates, WAFR, 12,000 bhp



a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

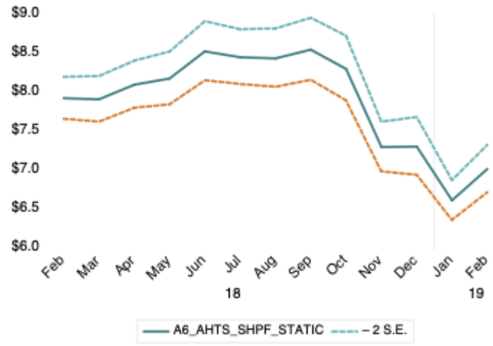
Forecast Performance Results

Variable Name	Description
A6_AHTS_SHP	AHTS 5yo, Medium 12,000 bhp



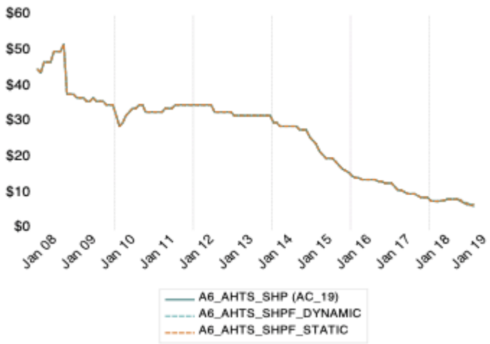
Forecast: A6_AHTS_SHPF_DYNAMIC	
Actual: A6_AHTS_SHP	
Forecast sample: 2018M02 2019M07	
Adjusted sample: 2018M02 2019M02	
Included observations: 13	
Root Mean Squared Error	0.254395
Mean Absolute Error	0.190875
Mean Abs. Percent Error	2.576156
Theil Inequality Coef.	0.016017
Bias Proportion	0.332729
Variance Proportion	0.135889
Covariance Proportion	0.531382
Theil U2 Coefficient	0.845091
Symmetric MAPE	2.517224

a)

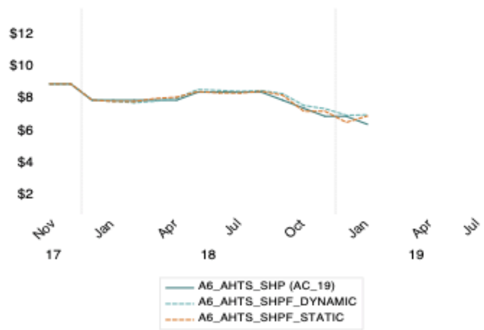


Forecast: A6_AHTS_SHPF_STATIC	
Actual: A6_AHTS_SHP	
Forecast sample: 2018M02 2019M02	
Included observations: 13	
Root Mean Squared Error	0.233188
Mean Absolute Error	0.179850
Mean Abs. Percent Error	2.460387
Theil Inequality Coef.	0.014767
Bias Proportion	0.045473
Variance Proportion	0.010373
Covariance Proportion	0.944153
Theil U2 Coefficient	0.789611
Symmetric MAPE	2.436562

b)



c)

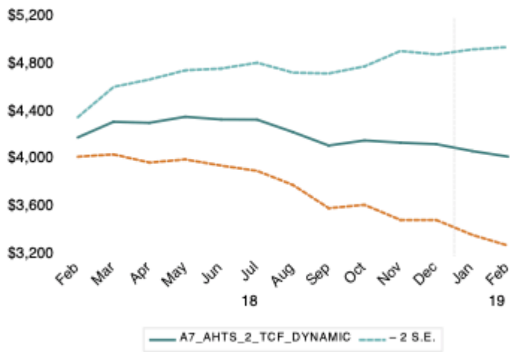


d)

a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Forecast Performance Results

Variable Name	Description
A7_AHTS_2_TC	AHTS 80t BP TC Rate, Global Indicator



Forecast: A7_AHTS_2_TCF_DYNAMIC
Actual: A7_AHTS_2_TC
Forecast sample: 2018M02 2019M02
Included observations: 13

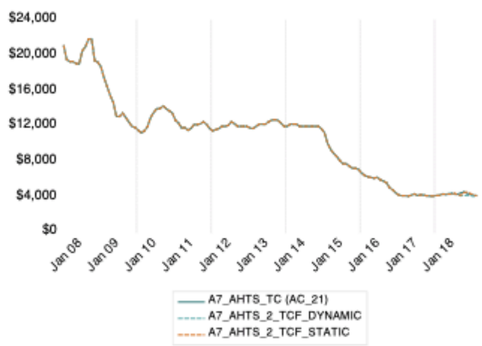
Root Mean Squared Error	177.2420
Mean Absolute Error	130.3920
Mean Abs. Percent Error	2.965712
Theil Inequality Coef.	0.020728
Bias Proportion	0.368023
Variance Proportion	0.000844
Covariance Proportion	0.631133
Theil U2 Coefficient	1.657928
Symmetric MAPE	3.045057

a)

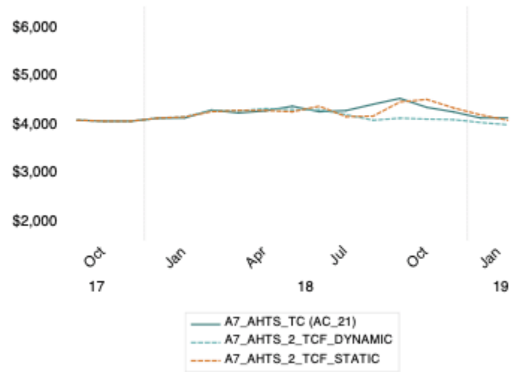
Forecast: A7_AHTS_2_TCF_STATIC
Actual: A7_AHTS_2_TC
Forecast sample: 2018M02 2019M02
Included observations: 13

Root Mean Squared Error	108.6233
Mean Absolute Error	88.36462
Mean Abs. Percent Error	2.024185
Theil Inequality Coef.	0.012561
Bias Proportion	0.010512
Variance Proportion	0.004452
Covariance Proportion	0.985035
Theil U2 Coefficient	1.022690
Symmetric MAPE	2.033289

b)



c)

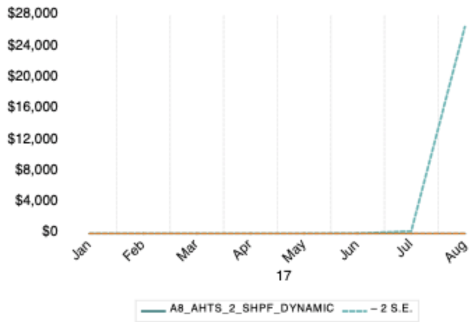


d)

a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

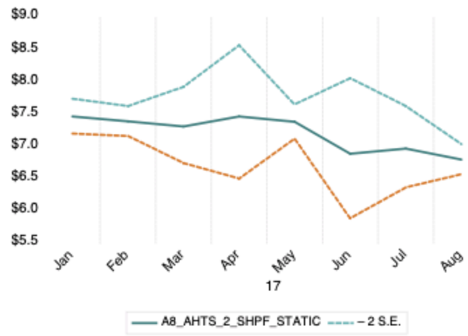
Forecast Performance Results

Variable Name	Description
A8_AHTS_2_SHP	AHTS 5yo, Medium 7,000 bhp



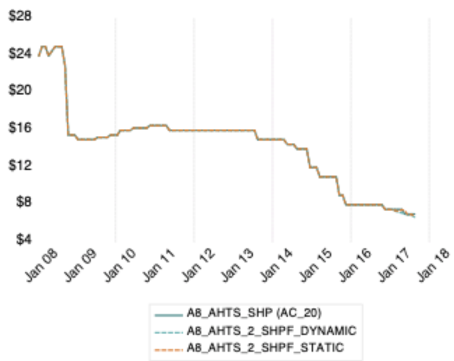
Forecast: A8_AHTS_2_SHPF_DYNAMIC	
Actual: A8_AHTS_2_SHP	
Forecast sample: 2017M01 2017M08	
Included observations: 8	
Root Mean Squared Error	0.227127
Mean Absolute Error	0.184028
Mean Abs. Percent Error	2.522789
Theil Inequality Coef.	0.015852
Bias Proportion	0.629920
Variance Proportion	0.000405
Covariance Proportion	0.369675
Theil U2 Coefficient	1.314235
Symmetric MAPE	2.571938

a)

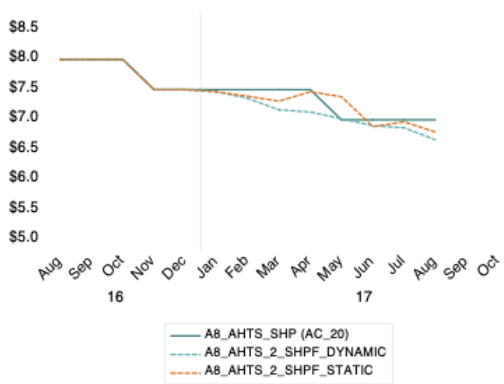


Forecast: A8_AHTS_2_SHPF_STATIC	
Actual: A8_AHTS_2_SHP	
Forecast sample: 2017M01 2017M08	
Included observations: 8	
Root Mean Squared Error	0.177708
Mean Absolute Error	0.138708
Mean Abs. Percent Error	1.936613
Theil Inequality Coef.	0.012285
Bias Proportion	0.060087
Variance Proportion	0.002249
Covariance Proportion	0.937664
Theil U2 Coefficient	1.018848
Symmetric MAPE	1.931673

b)



c)

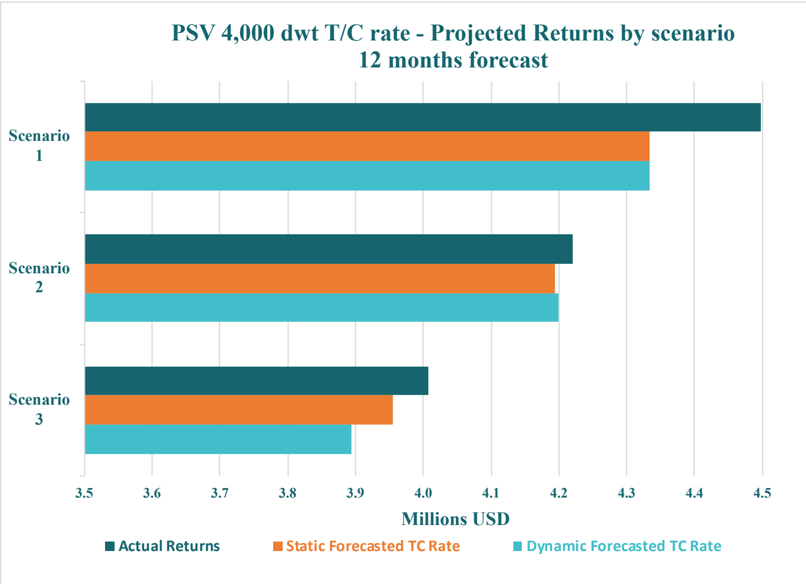


d)

a) Dynamic Forecast, b) Static Forecast, c) Historical data and Forecast Overview, d) Forecast Comparison with actual values.

Appendix 11

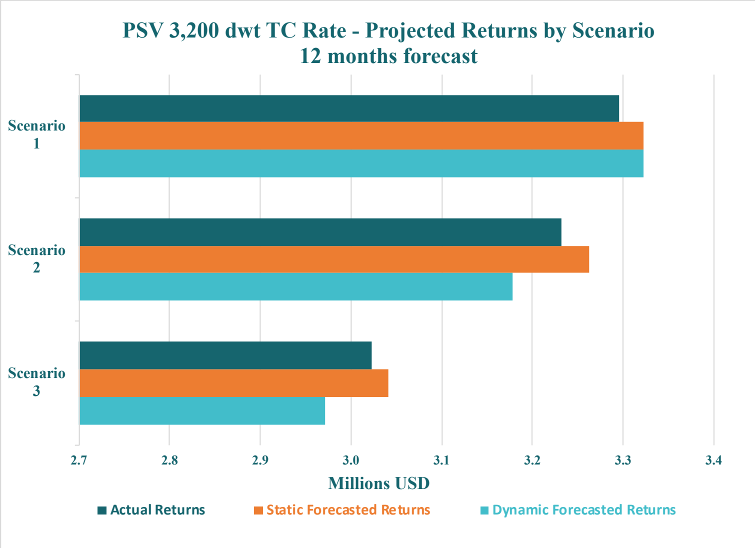
Scenarios comparison (Returns) for PSV 4,000 dwt TC Rate, Global Indicator



PSV 4,000 dwt TC Rate, Global Indicator				
Date	Days (Month)	Actual T/C Rate	Static Forecasted T/C rate	Dynamic Forecasted T/C rate
Feb-2018	28	$ 11,445.00	$ 11,029.41	$ 11,029.41
Mar-2018	31	$ 11,455.00	$ 11,248.48	$ 11,672.33
Apr-2018	30	$ 11,645.00	$ 11,494.35	$ 11,705.38
May-2018	31	$ 12,500.00	$ 11,734.45	$ 11,888.24
Jun-2018	30	$ 12,405.00	$ 11,688.58	$ 12,451.14
Jul-2018	31	$ 12,525.00	$ 11,840.05	$ 12,565.76
Aug-2018	31	$ 11,995.00	$ 12,022.54	$ 12,718.05
Sep-2018	30	$ 11,870.00	$ 12,167.72	$ 12,139.84
Oct-2018	31	$ 12,130.00	$ 12,359.05	$ 12,056.65
Nov-2018	30	$ 12,145.00	$ 12,456.41	$ 12,225.55
Dec-2018	31	$ 12,145.00	$ 12,378.38	$ 12,068.92
Jan-2019	31	$ 12,500.00	$ 12,385.19	$ 12,151.68
Feb-2019	28	$ 12,625.00	$ 12,410.85	$ 12,525.90

Dynamic Returns - Forecast				Static Returns - Forecast				Actual Returns			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures	Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures	Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 308,823.39	$ 308,823.39	$ 308,823.39	Feb-2018	$ 308,823.39	$ 308,823.39	$ 308,823.39	Feb-2018	$ 320,460.00	$ 320,460.00	$ 320,460.00
Mar-2018	$ 341,911.61	$ 341,911.61	$ 341,911.61	Mar-2018	$ 341,911.61	$ 341,911.61	$ 341,911.61	Mar-2018	$ 354,795.00	$ 354,795.00	$ 354,795.00
Apr-2018	$ 330,882.21	$ 330,882.21	$ 330,882.21	Apr-2018	$ 330,882.21	$ 330,882.21	$ 330,882.21	Apr-2018	$ 343,350.00	$ 343,350.00	$ 343,350.00
May-2018	$ 341,911.61	$ 341,911.61	$ 341,911.61	May-2018	$ 341,911.61	$ 341,911.61	$ 341,911.61	May-2018	$ 354,795.00	$ 354,795.00	$ 354,795.00
Jun-2018	$ 330,882.21	$ 330,882.21	$ -	Jun-2018	$ 330,882.21	$ 330,882.21	$ -	Jun-2018	$ 343,350.00	$ 343,350.00	$ -
Jul-2018	$ 341,911.61	$ 341,911.61	$ 367,041.50	Jul-2018	$ 341,911.61	$ 341,911.61	$ 389,538.47	Jul-2018	$ 354,795.00	$ 354,795.00	$ 388,275.00
Aug-2018	$ 341,911.61	$ -	$ 367,041.50	Aug-2018	$ 341,911.61	$ -	$ 389,538.47	Aug-2018	$ 354,795.00	$ -	$ 388,275.00
Sep-2018	$ 330,882.21	$ 365,031.54	$ 355,201.45	Sep-2018	$ 330,882.21	$ 364,195.27	$ 376,972.72	Sep-2018	$ 343,350.00	$ 356,100.00	$ 375,750.00
Oct-2018	$ 341,911.61	$ 377,199.26	$ 367,041.50	Oct-2018	$ 341,911.61	$ 376,335.12	$ 389,538.47	Oct-2018	$ 354,795.00	$ 367,970.00	$ 388,275.00
Nov-2018	$ 330,882.21	$ 365,031.54	$ -	Nov-2018	$ 330,882.21	$ 364,195.27	$ -	Nov-2018	$ 343,350.00	$ 356,100.00	$ -
Dec-2018	$ 341,911.61	$ 377,199.26	$ 383,729.87	Dec-2018	$ 341,911.61	$ 376,335.12	$ 374,136.66	Dec-2018	$ 354,795.00	$ 367,970.00	$ 376,495.00
Jan-2019	$ 341,911.61	$ 377,199.26	$ 383,729.87	Jan-2019	$ 341,911.61	$ 376,335.12	$ 374,136.66	Jan-2019	$ 354,795.00	$ 367,970.00	$ 376,495.00
Feb-2019	$ 308,823.39	$ 340,696.11	$ 346,594.72	Feb-2019	$ 308,823.39	$ 339,915.59	$ 337,929.89	Feb-2019	$ 320,460.00	$ 332,360.00	$ 340,060.00
Total Returns Dynamic	$ 4,334,556.91	$ 4,198,679.62	$ 3,893,909.24	**Total Returns Static**	$ 4,334,556.91	$ 4,193,634.13	$ 3,955,320.16	**Total Returns - Actual**	$ 4,497,885.00	$ 4,220,015.00	$ 4,007,025.00

Scenarios comparison (Returns) PSV 3,200 dwt TC Rate, Global Indicator



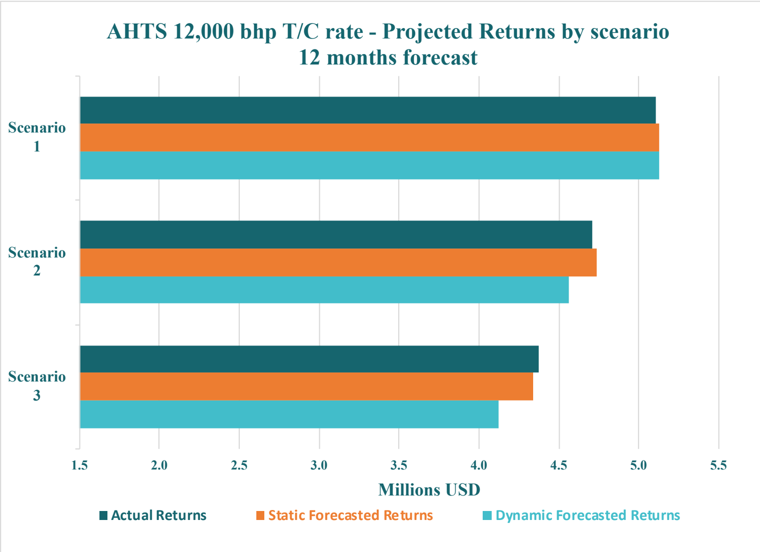
PSV 3,200 dwt TC Rate, Global Indicator				
Date	Days (Month)	Actual T/C Rate	Static Forecasted T/C rate	Dynamic Forecasted T/C rate
Feb-2018	28	$ 8,385.00	$ 8,454.00	$ 8,454.00
Mar-2018	31	$ 8,685.00	$ 8,624.20	$ 8,506.04
Apr-2018	30	$ 8,920.00	$ 8,662.59	$ 8,848.67
May-2018	31	$ 9,100.00	$ 9,067.40	$ 9,388.21
Jun-2018	30	$ 9,010.00	$ 9,135.64	$ 8,975.18
Jul-2018	31	$ 9,155.00	$ 9,159.05	$ 9,057.02
Aug-2018	31	$ 9,330.00	$ 9,031.67	$ 9,094.31
Sep-2018	30	$ 9,470.00	$ 9,102.25	$ 9,568.77
Oct-2018	31	$ 9,760.00	$ 9,334.25	$ 9,642.76
Nov-2018	30	$ 9,975.00	$ 9,232.63	$ 9,733.81
Dec-2018	31	$ 9,900.00	$ 9,225.91	$ 10,135.87
Jan-2019	31	$ 9,973.00	$ 9,306.49	$ 9,827.06
Feb-2019	28	$ 10,000.00	$ 9,419.64	$ 10,196.45

Dynamic Returns - Forecast			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 236,711.99	$ 236,711.99	$ 236,711.99
Mar-2018	$ 262,073.98	$ 262,073.98	$ 262,073.98
Apr-2018	$ 253,619.99	$ 253,619.99	$ 253,619.99
May-2018	$ 262,073.98	$ 262,073.98	$ 262,073.98
Jun-2018	$ 253,619.99	$ 253,619.99	$ -
Jul-2018	$ 262,073.98	$ 262,073.98	$ 283,930.48
Aug-2018	$ 262,073.98	$ -	$ 283,930.48
Sep-2018	$ 253,619.99	$ 273,067.62	$ 274,771.43
Oct-2018	$ 262,073.98	$ 282,169.87	$ 283,930.48
Nov-2018	$ 253,619.99	$ 273,067.62	$ -
Dec-2018	$ 262,073.98	$ 282,169.87	$ 286,003.31
Jan-2019	$ 262,073.98	$ 282,169.87	$ 286,003.31
Feb-2019	$ 236,711.99	$ 254,863.11	$ 258,325.57
Total Returns Dyn Fcst	$ 3,322,421.81	$ 3,177,681.87	$ 2,971,375.01

Static Returns - Forecast			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 236,711.99	$ 236,711.99	$ 236,711.99
Mar-2018	$ 262,073.98	$ 262,073.98	$ 262,073.98
Apr-2018	$ 253,619.99	$ 253,619.99	$ 253,619.99
May-2018	$ 262,073.98	$ 262,073.98	$ 262,073.98
Jun-2018	$ 253,619.99	$ 253,619.99	$ -
Jul-2018	$ 262,073.98	$ 262,073.98	$ 280,767.64
Aug-2018	$ 262,073.98	$ -	$ 280,767.64
Sep-2018	$ 253,619.99	$ 287,063.11	$ 271,710.62
Oct-2018	$ 262,073.98	$ 296,631.88	$ 280,767.64
Nov-2018	$ 253,619.99	$ 287,063.11	$ -
Dec-2018	$ 262,073.98	$ 296,631.88	$ 314,212.04
Jan-2019	$ 262,073.98	$ 296,631.88	$ 314,212.04
Feb-2019	$ 236,711.99	$ 267,925.57	$ 283,804.42
Total Returns Stat Fcst	$ 3,322,421.81	$ 3,262,121.33	$ 3,040,721.97

Actual Returns			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 234,780.00	$ 234,780.00	$ 234,780.00
Mar-2018	$ 259,935.00	$ 259,935.00	$ 259,935.00
Apr-2018	$ 251,550.00	$ 251,550.00	$ 251,550.00
May-2018	$ 259,935.00	$ 259,935.00	$ 259,935.00
Jun-2018	$ 251,550.00	$ 251,550.00	$ -
Jul-2018	$ 259,935.00	$ 259,935.00	$ 283,805.00
Aug-2018	$ 259,935.00	$ -	$ 283,805.00
Sep-2018	$ 251,550.00	$ 284,100.00	$ 274,650.00
Oct-2018	$ 259,935.00	$ 293,570.00	$ 283,805.00
Nov-2018	$ 251,550.00	$ 284,100.00	$ -
Dec-2018	$ 259,935.00	$ 293,570.00	$ 306,900.00
Jan-2019	$ 259,935.00	$ 293,570.00	$ 306,900.00
Feb-2019	$ 234,780.00	$ 265,160.00	$ 277,200.00
Total Returns - Actual	$ 3,295,305.00	$ 3,231,755.00	$ 3,023,265.00

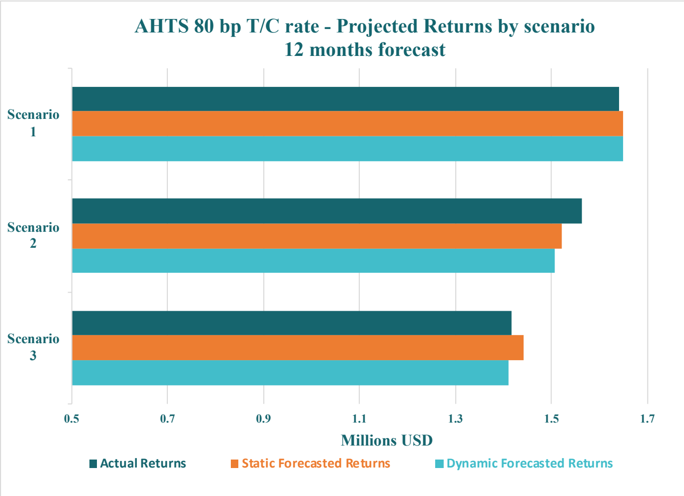
Scenarios comparison (Returns) AHTS 12,000 bhp TC Rates, WAFR



AHTS 12,000 bhp TC Rates, WAFR				
Date	Days (Month)	Actual T/C Rate	Static Forecasted T/C rate	Dynamic Forecasted T/C rate
Feb-2018	28	$ 13,000.00	$ 13,048.31	$ 13,048.31
Mar-2018	31	$ 13,000.00	$ 12,904.12	$ 12,856.71
Apr-2018	30	$ 13,000.00	$ 12,825.82	$ 12,913.17
May-2018	31	$ 13,000.00	$ 12,111.95	$ 12,297.32
Jun-2018	30	$ 13,000.00	$ 11,988.91	$ 12,872.64
Jul-2018	31	$ 13,000.00	$ 12,156.07	$ 13,262.05
Aug-2018	31	$ 13,000.00	$ 11,948.77	$ 12,764.47
Sep-2018	30	$ 13,000.00	$ 12,172.09	$ 13,142.55
Oct-2018	31	$ 13,000.00	$ 12,366.85	$ 13,292.98
Nov-2018	30	$ 13,000.00	$ 11,970.35	$ 12,615.72
Dec-2018	31	$ 13,500.00	$ 11,829.95	$ 12,723.96
Jan-2019	31	$ 13,500.00	$ 11,597.97	$ 13,304.42
Feb-2019	28	$ 13,500.00	$ 11,717.87	$ 13,834.98

Dynamic Returns - Forecast				Static Returns - Forecast				Actual Returns			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures	Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures	Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 365,352.75	$ 365,352.75	$ 365,352.75	Feb-2018	$ 365,352.75	$ 365,352.75	$ 365,352.75	Feb-2018	$ 364,000.00	$ 364,000.00	$ 364,000.00
Mar-2018	$ 404,497.68	$ 404,497.68	$ 404,497.68	Mar-2018	$ 404,497.68	$ 404,497.68	$ 404,497.68	Mar-2018	$ 403,000.00	$ 403,000.00	$ 403,000.00
Apr-2018	$ 391,449.37	$ 391,449.37	$ 391,449.37	Apr-2018	$ 391,449.37	$ 391,449.37	$ 391,449.37	Apr-2018	$ 390,000.00	$ 390,000.00	$ 390,000.00
May-2018	$ 404,497.68	$ 404,497.68	$ 404,497.68	May-2018	$ 404,497.68	$ 404,497.68	$ 404,497.68	May-2018	$ 403,000.00	$ 403,000.00	$ 403,000.00
Jun-2018	$ 391,449.37	$ 391,449.37	$ -	Jun-2018	$ 391,449.37	$ 391,449.37	$ -	Jun-2018	$ 390,000.00	$ 390,000.00	$ -
Jul-2018	$ 404,497.68	$ 404,497.68	$ 376,838.16	Jul-2018	$ 404,497.68	$ 404,497.68	$ 411,123.50	Jul-2018	$ 403,000.00	$ 403,000.00	$ 403,000.00
Aug-2018	$ 404,497.68	$ -	$ 376,838.16	Aug-2018	$ 404,497.68	$ -	$ 411,123.50	Aug-2018	$ 403,000.00	$ -	$ 403,000.00
Sep-2018	$ 391,449.37	$ 365,162.57	$ 364,682.09	Sep-2018	$ 391,449.37	$ 394,276.48	$ 397,861.46	Sep-2018	$ 390,000.00	$ 390,000.00	$ 390,000.00
Oct-2018	$ 404,497.68	$ 377,334.66	$ 376,838.16	Oct-2018	$ 404,497.68	$ 407,419.03	$ 411,123.50	Oct-2018	$ 403,000.00	$ 403,000.00	$ 403,000.00
Nov-2018	$ 391,449.37	$ 365,162.57	$ -	Nov-2018	$ 391,449.37	$ 394,276.48	$ -	Nov-2018	$ 390,000.00	$ 390,000.00	$ -
Dec-2018	$ 404,497.68	$ 377,334.66	$ 366,728.47	Dec-2018	$ 404,497.68	$ 407,419.03	$ 394,442.67	Dec-2018	$ 403,000.00	$ 403,000.00	$ 418,500.00
Jan-2019	$ 404,497.68	$ 377,334.66	$ 366,728.47	Jan-2019	$ 404,497.68	$ 407,419.03	$ 394,442.67	Jan-2019	$ 403,000.00	$ 403,000.00	$ 418,500.00
Feb-2019	$ 365,352.75	$ 340,818.40	$ 331,238.62	Feb-2019	$ 365,352.75	$ 367,991.38	$ 356,270.80	Feb-2019	$ 364,000.00	$ 364,000.00	$ 378,000.00
Total Returns Dyn Fcst	$ 5,127,986.76	$ 4,564,892.04	$ 4,125,689.60	**Total Returns Stat Focst**	$ 5,127,986.76	$ 4,740,545.99	$ 4,342,185.59	**Total Returns - Actual**	$ 5,109,000.00	$ 4,706,000.00	$ 4,374,000.00

Scenarios comparison (Returns) AHTS 80t BP TC Rate, Global Indicator



AHTS 80t BP TC Rate, Global Indicator				
Date	Days (Month)	Actual T/C Rate	Static Forecasted T/C rate	Dynamic Forecasted T/C rate
Feb-2018	28	$ 4,175.00	$ 4,196.79	$ 4,196.79
Mar-2018	31	$ 4,340.00	$ 4,328.71	$ 4,306.23
Apr-2018	30	$ 4,280.00	$ 4,319.65	$ 4,330.92
May-2018	31	$ 4,325.00	$ 4,370.64	$ 4,330.52
Jun-2018	30	$ 4,420.00	$ 4,348.30	$ 4,302.90
Jul-2018	31	$ 4,305.00	$ 4,346.56	$ 4,418.23
Aug-2018	31	$ 4,330.00	$ 4,242.48	$ 4,201.92
Sep-2018	30	$ 4,460.00	$ 4,128.67	$ 4,213.84
Oct-2018	31	$ 4,580.00	$ 4,171.19	$ 4,505.94
Nov-2018	30	$ 4,395.00	$ 4,152.43	$ 4,559.40
Dec-2018	31	$ 4,300.00	$ 4,140.22	$ 4,382.07
Jan-2019	31	$ 4,175.00	$ 4,081.53	$ 4,239.05
Feb-2019	28	$ 4,175.00	$ 4,035.01	$ 4,127.42

Dynamic Returns - Forecast			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 117,510.25	$ 117,510.25	$ 117,510.25
Mar-2018	$ 130,100.63	$ 130,100.63	$ 130,100.63
Apr-2018	$ 125,903.84	$ 125,903.84	$ 125,903.84
May-2018	$ 130,100.63	$ 130,100.63	$ 130,100.63
Jun-2018	$ 125,903.84	$ 125,903.84	$ -
Jul-2018	$ 130,100.63	$ 130,100.63	$ 134,743.31
Aug-2018	$ 130,100.63	$ -	$ 134,743.31
Sep-2018	$ 125,903.84	$ 123,860.05	$ 130,396.75
Oct-2018	$ 130,100.63	$ 127,988.72	$ 134,743.31
Nov-2018	$ 125,903.84	$ 123,860.05	$ -
Dec-2018	$ 130,100.63	$ 127,988.72	$ 128,346.70
Jan-2019	$ 130,100.63	$ 127,988.72	$ 128,346.70
Feb-2019	$ 117,510.25	$ 115,602.71	$ 115,926.05
Total Returns Dyn Fcst	$ 1,649,340.30	$ 1,506,908.78	$ 1,410,861.49

Static Returns - Forecast			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 117,510.25	$ 117,510.25	$ 117,510.25
Mar-2018	$ 130,100.63	$ 130,100.63	$ 130,100.63
Apr-2018	$ 125,903.84	$ 125,903.84	$ 125,903.84
May-2018	$ 130,100.63	$ 130,100.63	$ 130,100.63
Jun-2018	$ 125,903.84	$ 125,903.84	$ -
Jul-2018	$ 130,100.63	$ 130,100.63	$ 136,965.06
Aug-2018	$ 130,100.63	$ -	$ 136,965.06
Sep-2018	$ 125,903.84	$ 126,415.12	$ 132,546.83
Oct-2018	$ 130,100.63	$ 130,628.96	$ 136,965.06
Nov-2018	$ 125,903.84	$ 126,415.12	$ -
Dec-2018	$ 130,100.63	$ 130,628.96	$ 135,844.19
Jan-2019	$ 130,100.63	$ 130,628.96	$ 135,844.19
Feb-2019	$ 117,510.25	$ 117,987.45	$ 122,697.98
Total Returns Stat Fcst	$ 1,649,340.30	$ 1,522,324.40	$ 1,441,443.73

Actual Returns			
Forecasted Dates	Scenario No. 1 Long Term 1 year	Scenario No. 2 Six Months	Scenario No. 3 4 months fixtures
Feb-2018	$ 116,900.00	$ 116,900.00	$ 116,900.00
Mar-2018	$ 129,425.00	$ 129,425.00	$ 129,425.00
Apr-2018	$ 125,250.00	$ 125,250.00	$ 125,250.00
May-2018	$ 129,425.00	$ 129,425.00	$ 129,425.00
Jun-2018	$ 125,250.00	$ 125,250.00	$ -
Jul-2018	$ 129,425.00	$ 129,425.00	$ 133,455.00
Aug-2018	$ 129,425.00	$ -	$ 133,455.00
Sep-2018	$ 125,250.00	$ 133,800.00	$ 129,150.00
Oct-2018	$ 129,425.00	$ 138,260.00	$ 133,455.00
Nov-2018	$ 125,250.00	$ 133,800.00	$ -
Dec-2018	$ 129,425.00	$ 138,260.00	$ 133,300.00
Jan-2019	$ 129,425.00	$ 138,260.00	$ 133,300.00
Feb-2019	$ 116,900.00	$ 124,880.00	$ 120,400.00
Total Returns - Actual	$ 1,640,775.00	$ 1,562,935.00	$ 1,417,515.00

Appendix 12

Coefficients resulting from the models (T/C rates)

	0.861	-0.067
	PSV 3,200 TC Rate Global %	**North America DS Utilization %**
Assumed Independent Variable Increment	10%	10%
PSV 4,000 dwt TC Rate		
Expected Dependent Variable Change	8.6%	-0.7%

Coefficient	0.448	0.286	-0.052	-0.269
	Independent Variables			
	PSV 4,000 dwt TC Rate %	**AHTS 80t BP TC Rate %**	**Laid-Up Vessels: OSV Total %**	**Fleet > FPSO Conversions %**
Assumed Independent Variable Increment	10	10	10	10
PSV 3,200 dwt TC Rate				
Expected Dependent Variable Change	4.5 %	2.9 %	-0.5 %	-2.7 %

Coefficients resulting from the models (T/C rates)

	⇧ 0.291	⇧ 0.196	⇩ -0.076	⇩ -0.183
	PSV/Supply Orderbook	**MGO Bunker Price - $/Tonne**	**UK-Active Jack-Ups**	**S. America-Active Floaters**
	%	**%**	**%**	**%**
Assumed Independent Variable Increment	10	10	10	10
AHTS 12,000 bhp TC Rates - Increment Expected Dependent Variable Change	2.9 %	2.0 %	-0.8 %	-1.8 %

	⇧ 0.261	⇧ 0.242	⇧ 0.189	⇧ 0.054	⇧ 0.016	⇩ -0.146
	PSV 4,000 dwt TC Rate	**S. America-Active Floaters**	**AHTS 12,000 bhp TC Rates, S.E Asia**	**Orderbook > Mob. Prod. > SS Prod**	**PSV 500-899m² Spot Rate, N. Sea**	**S. America-Active Drillships**
	%	**%**	**%**	**%**	**%**	**%**
Assumed Independent Variable Increment	10	10	10	10	10	10
AHTS 80t BP TC Rate - Increment Expected Dependent Variable Change	2.6 %	2.4 %	1.9 %	0.5 %	0.2 %	-1.5 %

Coefficients resulting from the models (Second-hand price)

	0.427	0.422	0.285	0.065	-0.291	-0.895
	PSV 700m² deck 5yo - SHP	AHTS 12,000 bhp 5yo - SHP	PSV 4,000 dwt TC Rate	MGO Bunker Price	PSV 3,200 dwt TC Rate	Fleet > Mobile Production
	%	%	%	%	%	%
Assumed Independent Variable Increment	10	10	10	10	10	10
PSV 800m² deck 5yo -SHP Expected Dependent Variable Change	4.3 %	4.2 %	2.9 %	0.7 %	-2.9 %	-9.0 %

Coefficient	0.475	0.468	0.076	0.012	-0.083	-0.123
	Independent Variables					
	a) AHTS 12,000 bhp 5yo - SHP	**b) PSV 800m² deck 5yo - SHP**	**c) PSV 750-899m² TC Rates, GOM**	**d) PSV 500-899m² Spot, N. Sea**	**e) AHTS 18,000 bhp TC Rates, Brazil**	**f) AHTS 12,000 bhp TC Rates, S.E Asia**
	%	**%**	**%**	**%**	**%**	**%**
Assumed Independent Variable Increment	10	10	10	10	10	10
PSV 700m2 deck 5yo - SHP Expected Dependent Variable Change	4.7 %	4.7 %	1.2 %	1.0 %	-0.8 %	-0.8 %

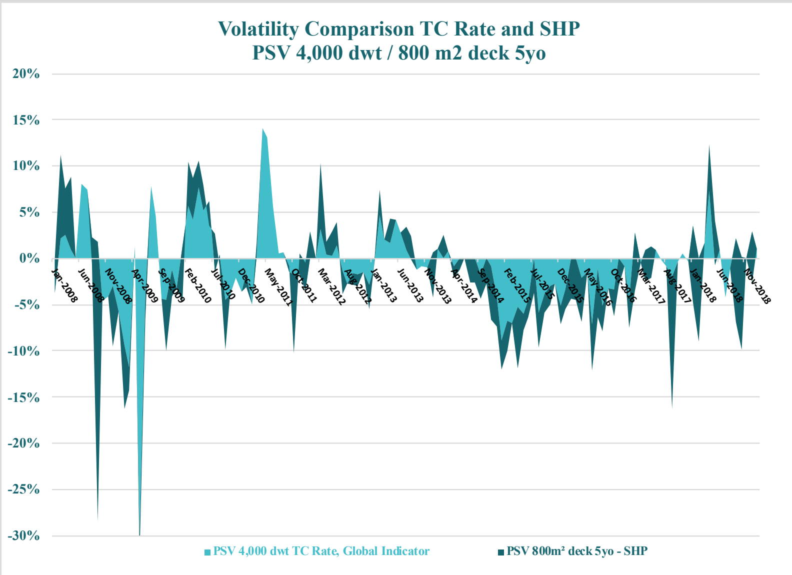
Coefficients resulting from the models (Second-hand price)

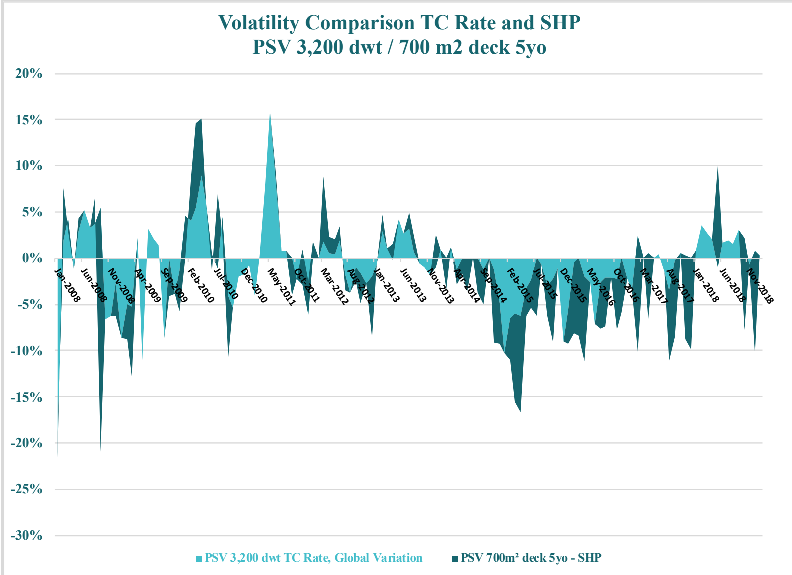
	0.400	0.255	0.096	0.081	-0.567
	*PSV 700m² deck 5yo - SHP	*PSV 800m² deck 5yo - SHP	North Sea- 3,500-10,000 ft Utilisation	Brent Crude Oil Price	Global Oil Prod
	%	**%**	**%**	**%**	**%**
Assumed Independent Variable Increment	10	10	10	10	10
AHTS 12,000 bhp 5yo - SHP					
Expected Dependent Variable Change	4.0 %	2.6 %	1.2 %	1.2 %	0.3 %

	0.261	0.242	0.189	0.054	0.016	-0.146
	*PSV 4,000 dwt TC Rate $/day	S. America- Active Floaters No.	AHTS 12,000 bhp TC Rates, S.E Asia $/day	Orderbook > Mob. Prod. > SS Prod No.	PSV 500-899m² Spot Rate, N. Sea $/day	S. America- Active Drillships No.
Assumed Independent Variable Increment	**%**	**%**	**%**	**%**	**%**	**%**
	10	10	10	10	10	10
AHTS 80t BP TC Rate						
Expected Dependent Variable Change	2.6 %	2.4 %	1.9 %	0.5 %	0.2 %	-1.5 %

Appendix 13

Volatility and fluctuation comparison between pair of variables (T/C rates Vs Second-hand price)





Volatility and fluctuation between pair of variables (T/C rates Vs Second-hand price)